POWER

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Steam

WHAT makes steam have pressure? If a battery of machine guns peppered a sheet of armor plate so that a continual stream of bullets fell upon every part of its surface the plate would be subjected to some pressure, would it not? And that pressure on any unit of area would depend upon the weight and velocity of the bullets and the number of impacts received by that area per second.

Similarly, the pressure exerted by steam is due to the bombardment of the molecules of which the steam is composed. In the water these molecules are held together by their mutual attraction as the planets are held to the sun and revolve about each other probably in much the same manner.

At any given instant some are moving faster than the average and some more slowly. If one of the fast-moving molecules happens to approach the surface in a favorable direction, it may be able to break away from the bondage of the liquid and become a free molecule of vapor.

For any given temperature a certain number of molecules per second will be able to break away from each square inch of liquid surface. This is half of the picture. The molecules of vapor are shooting around in haphazard fashion and in all directions. Necessarily, some of them dive back into the liquid. The more molecules present in each cubic inch of vapor the greater will be the number diving back into each square inch of liquid surface.

With the water kept at any particular temperature in a closed vessel, the number breaking away from the liquid each second will remain constant, but the number diving back will continually increase until the outgo equals the input.

This state of balance constitutes the saturated condition. When it is reached, the density of the vapor must correspond to the water temperature. With a given vapor density and temperature the pressure must also be constant, since it is only the hail of the vapor molecules on the walls of the vessel that produces pressure. So for each temperature saturated vapor has only one density and one pressure.

Some time our knowledge of molecular physics and of the mass and the velocities corresponding to different temperatures may be sufficiently intimate to enable us to calculate rationally the relation of temperature to pressure and the amount of energy—that is, heat—necessary to tear the molecules loose from their bondage, but now we are obliged to determine these quantities experimentally.

The relations between pressure and temperature were first determined by a French physicist, Henry Victor Regnault, and published in 1847. His determinations were for years the basis of our tables of the physical properties of steam, but they covered only the lower pressure range.

With the modern increase in steam pressures and the use of superheat, more extended information became necessary and some two years ago a movement for such a study was inaugurated largely through the initiative of George A. Orrok.

The extreme delicacy and difficulty of such a research can be appreciated only by those who have dealt with the subject. Three great scientific institutions are concentrating their skill and patience upon separate phases of the problem. In the end their results will be combined in new and better steam tables for the benefit of the engineering profession and indirectly of the world at large.

The series of articles beginning in this issue will give the reader an idea of the magnitude of the work and its importance to all who work with steam.

Steam Research Promises Much for Power-Plant Engineers

By P. W. SWAIN*

WHY steam-table research? Do we not already have steam tables? These questions arise when one is first informed of the money and energy now being expended in perfecting and extending the data underlying the steam tables. Yet a little study of the matter will show the immense practical importance of this work to the engineering profession in general and to power-plant engineers in particular.

We now have not one set of steam tables but many. In this country the tables of Marks & Davis, Goodenough and Peabody are all extensively used, while Great Britain uses these to a smaller extent, her chief reliance being placed on Callendar's tables. Still others find favor in European countries, in particular the recently published (1923) tables of Knoblauch and his coworkers of Munich, Germany. Each of these tables differs somewhat from the others in the values given. As an example, consider the case of steam at 200 lb. absolute pressure and 200 deg. superheat. According to three authorities, selected at random, the values for temperature, specific volume and total heat are as shown in the accompanying table.

While the temperatures are the same in the three cases, there is a substantial variation in the values for specific volume and total heat. Many other illustrations could be given of the variations from one set of steam tables to another.

The general reasons for these discrepancies are not hard to find. In the first place, as every scientist knows, exact measurements are impossible; some error must always exist in any set of tables based on physical measurements. In the second place measurements of the properties of steam are of an extremely difficult nature. As a result, different investigators have obtained appreciably different results. Furthermore, these tables cover a wide range of temperature and pressure, and with the limited experimental data there are large gaps that must be filled according to the judgment of the compiler. The differences are greatest at the higher pressures and temperatures, where the experimental difficulties are greatest and the least data are available.

In the various tables there is also lack of agreement on the value of the heat unit. Even the definition varies. Marks and Davis define the B.t.u. as the *average* amount of heat required to raise the temperature of one pound of water one degree over the range from 32 deg. F. to 212. Others define it as the heat required to warm one pound of water one degree starting at some convenient and arbitrarily chosen temperature.

Aside from this fundamental matter of definition there is no agreement as to correct value for the mechanical equivalent of heat; that is, the number of foot-pounds of work required to heat one pound of water one degree under given conditions. However, these differences in definition are of minor importance compared with experimental discrepancies. The former can be settled by conference and agreement, but new data can be obtained only by patient research.

The first extensive investigation of the properties of steam was made by Regnault. Considering the fact that his work was done back in 1847, the results obtained by this famous French physicist are surprisingly accurate. In recent times partial investigations of steam properties have been made by Knoblauch, Jacob, Mollier, Winkhaus, Raisch, Linde, Klebe, Hausen, Holborn, Henning, Callendar, Brinkworth, Trueblood and others. The most recent work is represented by the 1923 tables of Knoblauch, Raisch and Hausen.

From what has been said it is clear that all existing steam tables contain appreciable errors. While these are probably small in the lower ranges of pressure and temperature, they are believed to be considerable in the upper ranges, at least for volumes and heat quantities. In fact, a large part of the higher pressure range has never been covered by experimental results, the steam-table data in these ranges being obtained by extrapolating—that is, extending the curves or equations for the lower ranges. Extrapolation is always a risky process.

Practically, this condition was not very serious ten years ago, when high pressures and temperatures were merely scientific curiosities, and the design of power-plant apparatus had not reached its present stage of refinement. The recent phenomenal growth of the power industry, resulting in the expenditure of many millions of dollars upon the design and construction of improved power-plant equipment, and the practical consideration of the value of much higher steam pressures and temperatures, has changed this situation entirely.

Realizing the seriousness of this condition, a group of fourteen prominent scientists and engineers met in Cambridge, Mass., at the instance of George A. Orrok, to discuss the matter and see what could be done.

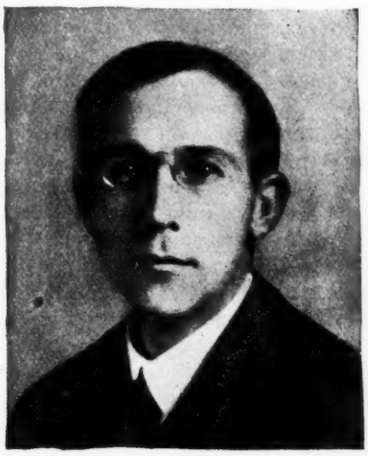
THREE great American Institutions — the Bureau of Standards, M.I.T. and Harvard— are engaged in perfecting and extending steam-table data. The research work, carried on by skilled physicists, is sponsored by the A.S.M.E. and financially backed by prominent engineers and manufacturers. The most difficult part of the task—the design, construction and testing of the experimental apparatus—is nearing completion. When the final data are ready, results from the three institutions will be combined and incorporated in new steam tables which will be of tremendous value to the whole engineering profession, and in particular to those who design, test and operate power-plant equipment.

COMPARATIVE STEAM-TABLE VALUES

Authority	Temperature, Deg. F.	Specific Volume, Cu.ft. per Lb.	Total Heat B.t.u. per Lb.
Marks & Davis	581.9	3.04	1,307.7
Goodenough	581.9	3.02	1,312.6
Callendar	581.9	3.016	1,317.1

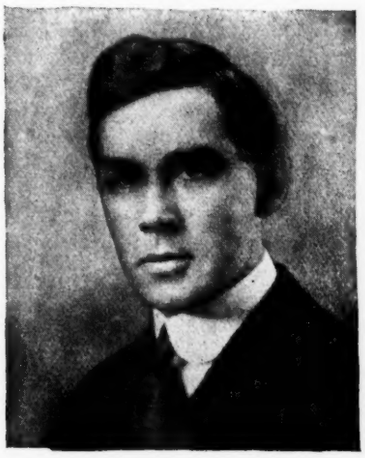
*Assistant Editor of *Power*.

Builders of the New Steam Tables

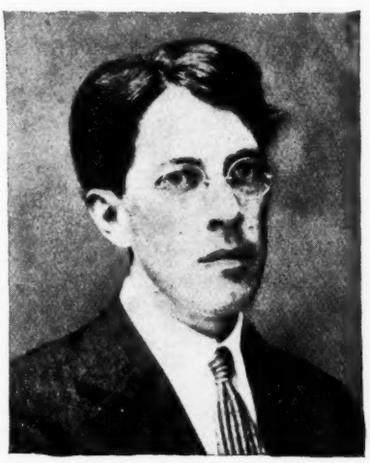


Nathan S. Osborne

George A. Orrok



Harvey N. Davis



H. F. Stimson

THE MOVING SPIRIT

George A. Orrok, Consulting Engineer, New York Edison Co.; Graduate Lecturer in Mechanical Engineering, Yale University.

BUREAU OF STANDARDS

Nathan S. Osborne, Physicist; Engineer of Mines. Research on alcohol, ammonia, methane, etc.

H. F. Stimson, Physicist; A. B. (Clark College); A.B. and Ph.D. (Clark University); Research on sound, ammonia, methane.

HARVARD

Harvey N. Davis, Professor of Mechanical Engineering; A.B. and A.M. (Brown), Ph.D. (Harvard); Co-author of Marks & Davis Steam Tables, etc.; Consulting Engineer.

Robert V. Kleinschmidt, Research Fellow; A.M. (Physics); S.B. in mechanical engineering; S.D.; Previous research on aeronautic power-plants, thermometry and cryogenics.

MASS. INSTITUTE OF TECHNOLOGY

Frederick G. Keyes, in charge of department of chemistry and director research laboratory of physical chemistry; B.S. (R. I. College); M.S. & Ph.D. (Brown); Previous research on gas metabolism of bacteria, equilibria measurements, kinetic theory, gas and liquid phase, isometrics, properties of ammonia, etc.

Robert S. Taylor, Research Associate in Physical Chemistry; B.A. & M.A. (Texas); Ph.D. (M.I.T.); Previous research on ether vapor, methane, nitrogen, melting point of ice.

Leighton B. Smith, Research Associate in Physical Chemistry; S.B., S.M. & Ph.D. (all M.I.T.); Previous research on ether, methane, nitrogen, iron nitrates and ice.

R. V. Kleinschmidt

Frederick G. Keyes

Robert S. Taylor

Leighton B. Smith

This was in June, 1921. As a result of this conference the A.S.M.E. agreed to sponsor an extensive program of steam-table research. A Steam Table Research Committee was appointed consisting of George A. Orrok (chairman), D. S. Jacobus and Arthur M. Greene. It was due largely to the vision and hard work of this committee that sufficient funds were raised to start the work and continue it up to the present stage.

First of all it was agreed that this investigation, to be of any value at all, would have to surpass in accuracy and range anything of the kind before attempted. Such an investigation requires not only money but also institutions that have the necessary men and facilities for undertaking research of a highly specialized nature. Although the results were to be mainly for the benefit of the engineering profession, the problems were such as to be best handled by scientists who combined a knowledge of mathematical thermodynamics with experimental ingenuity and experience in designing and handling highly refined small-scale apparatus.

Data for Higher Ranges Urgently Needed

It should be emphasized that the most difficult and yet the most important part of this work lies in increasing the range of pressures and temperatures. Repetition of previous work in the lower ranges is merely to make a final settlement of any existing disagreement. That work in the higher ranges has more than purely scientific interest is evident from the fact that many plants are now being designed for pressures of 400 to 500 lb. Germany has boilers operating at 900 lb. A 1,500-lb. boiler is operating in Sweden. Experiments are being made with steam generation at the "critical" pressure (3,200 lb.) in England, while two 1,200-lb. installations (Weymouth and Calumet) are being made in the United States. In short, high pressures have definitely entered the field of practice.

Consideration of the ability of various agencies to undertake the work that was deemed essential, led eventually to a division of the experimental problem into three parts, as a tentative working basis. There was first the matter of making a very accurate determination of the specific heat of water, both for recomputing the mechanical equivalent of heat (this constant entering into the computation of the entire steam table) and for determining the properties of water above 212 deg. F. where actual experimental data are practically non-existent. The Bureau of Standards, being especially equipped for and experienced in investigations of this nature, was selected for this part of the work.

The second problem was to determine the relation between the pressure, temperature and volume of superheated steam over as wide a range of pressure and temperature as possible. This portion of the investigation was undertaken by the Massachusetts Institute of Technology, where similar work with other substances had been carried on since 1910.

The Harvard Engineering School undertook to investigate the "Joule-Thomson" effect; that is, the change of temperature of superheated steam when throttled under conditions such that no heat passes into or out of the steam during the throttling process. This work, as will be shown in a later article, will be extremely useful for determining the properties of superheated steam.

The direct determination of the total heat of saturated steam was later assigned to the Bureau or Standards, because the apparatus there developed for measuring the specific heat of water was ideally suited for this other determination as well.

In brief, then, the Bureau of Standards was to find the heat required to raise the temperature of one pound of water one degree at various temperatures, the number of foot-pounds of energy in one B.t.u. and the heat required to evaporate one pound of boiling water at various temperatures; the Massachusetts Institute of Technology was to find the saturation temperatures and the volumes of one pound of steam at various pressures and superheats, while the Harvard Engineering School was to determine how much heat is required to superheat one pound of steam various amounts.

These data would evidently insure the following columns in the steam table: Heat of the liquid, heat of vaporization, specific volume, specific weight and total heat. With these and the known laws of thermodynamics, all the other steam-table data (entropy, internal energy, etc.) can be figured without difficulty.

As a matter of fact the known theoretical relations between the steam-table quantities are such that but little is needed for the computation of complete tables beyond any *one* of three sets of experiments: Those made at M.I.T., those made at Harvard or those of Knoblauch for the specific heat of superheated steam. Calling these three sets of experiments A, B and C respectively, it is then evident that they give a triple check, since A must check with B, B with C and A with C. Since totally different methods are used in these three sets of experiments, close agreement in this triple check will warrant the greatest confidence in the accuracy of the resulting steam tables. When, in addition, it is considered that the results must be consistent with the direct measurements of the specific heat of water and the latent heat of evaporation, it is clear that the solidest kind of a foundation is being laid for steam engineering progress.

Job Not So Easy as It Looks

The question may be raised by the practical engineer as to why such an apparently straightforward problem should be divided up among three institutions. Why not give a single engineer or physicist the job of taking one pound of water at 32 deg. F., heating it up to the boiling point at various pressures, evaporating it and superheating it, letting him measure the heat required, the temperature and the volume at all stages? It sounds easy, and in fact would be easy if an error of one or two per cent were permissible. But if results accurate to less than one-tenth per cent are to be obtained, as is desired and anticipated, the problem at once becomes extremely difficult.

Much has been said of the three great institutions engaged in this work, but the institution merely furnishes the atmosphere and the facilities for the man. To the research workers themselves must go most of the credit for the results accomplished. In spite of the wonderful gifts of science to the common welfare, the research worker still receives far less recognition than is his due. As its share toward remedying this situation *Power* takes pleasure in presenting with this article photographs of the men directly responsible for this work.

The problems encountered by these men, their methods of work and the results they hope to obtain will be taken up in three special articles, each of which will deal with the work at one of the three institutions.

Oil System Specially Designed for Municipal Pumping Plant

TELLS why continuity of service is highly important and how a low renewal cost is obtained. Gravity tank provides a fifteen-minute supply without pump, and indicating devices check operation.

By H. R. CADY*

SEVERAL years of experience by the Philadelphia Bureau of Water in the operation of geared-turbine-driven pumping units of various speeds, makes and types, had shown how essential is the very best of lubrication. This is not only from the viewpoint of conserving energy and reducing resultant operating cost, but also for keeping down maintenance costs, insuring uninterrupted service and a reasonable length of life of the units. The Queen Lane Station forms so important a link in the Philadelphia water-supply system that lubricant troubles and especially gear lubrication trouble, which often means a considerable shutdown, would constitute a serious menace to the service. The main points covered by the design of this lubricating system are given at the end of this article.

The four main units in Fig. 1 are believed to be the highest-powered turbine-driven water pumps ever put in service. Each consists of two 30-in. single-stage centrifugal pumps, connected in series and driven at 550 r.p.m. through a reduction gear by a 2,500-hp. compound steam turbine, the high-pressure shaft of which runs at 4,000 r.p.m., while the low-pressure shaft runs at 3,000. These units have a working head of 275 feet.

The two circulating water-pumps are also driven through reduction gearing by high-pressure cross-compound turbines. All lubricating equipment is located in the engine room except the supply tanks, which are in an adjoining room at the level of the main gallery.

Two supply tanks, Fig. 2, located at an elevation of about twenty feet above main bearings, are connected through a loop supply line to all bearings and gears of four main units and two circulating water units. Drain lines lead from bearing wells to two return tanks at an elevation of about twelve feet below main bearings. Return tanks are connected from the bottom to the three single direct-acting return pumps. Discharge lines from these pumps run to three coolers and from them to supply tanks.

From the bottoms of supply tanks, lines connect to a used oil tank at an elevation of about ten feet above the main bearings. A connection from the bottom of the latter extends above the inlet of the two centrifugal oil purifiers about three feet lower.

The outlet of each purifier is piped over the top of

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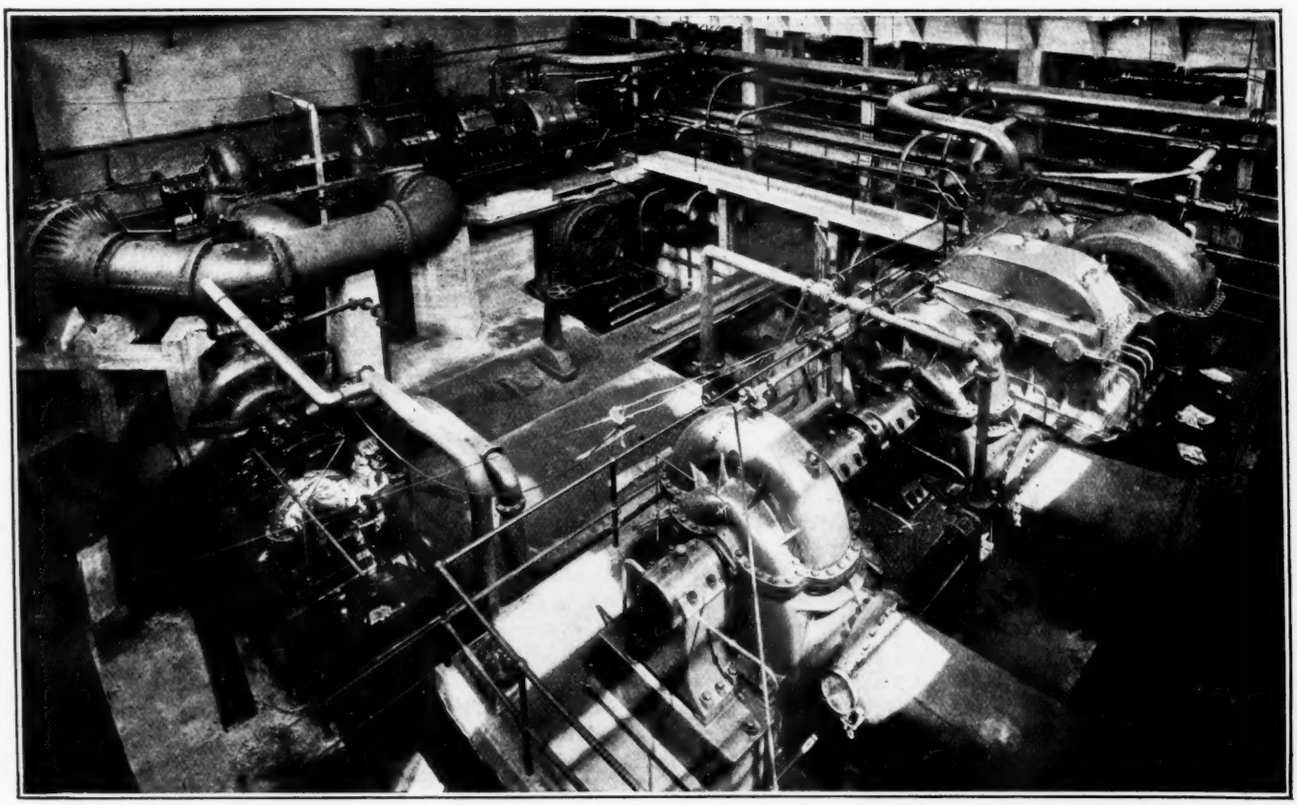


Fig. 1—Gravity oil system lubricates centrifugal pumps geared to cross-compound turbine

the purified-oil tanks. Direct-acting centrifugal oil pumps transfer the lubricant from this point to the main supply tanks. The oil levels in the main welded steel supply tanks of 300-gal. each are indicated by elevation gages operated by floats. These are on the walls opposite. There is an alarm bell and colored lights visible from all parts of the engine room to indicate if an oil-supply tank should go above or below the required limit of level.

The return oil is collected by means of two welded steel return tanks of 3,000 gal. each. They are comparatively long and shallow so that a sufficient head for the drainage may be provided without placing these for the application of the purifier. This tank has a capacity of 3,000 gal. and is of welded steel.

Oil lines are of large size, the main supply being 4 in., the drain line 5, and the branch lines 3 and 4 respectively. Supply lines are of galvanized rough steel and drain lines of plain rough steel.

A sight-feed indicator, as shown in Fig. 3 is placed on each bearing where the flow of oil may be seen easily. Any choking of the supply line will therefore be easily noticeable. Gears are lubricated by oil emitted from a series of nozzles. These strike the contact area between pinions and gears where the tendency of pinions and gears is to run together, so that the oil is

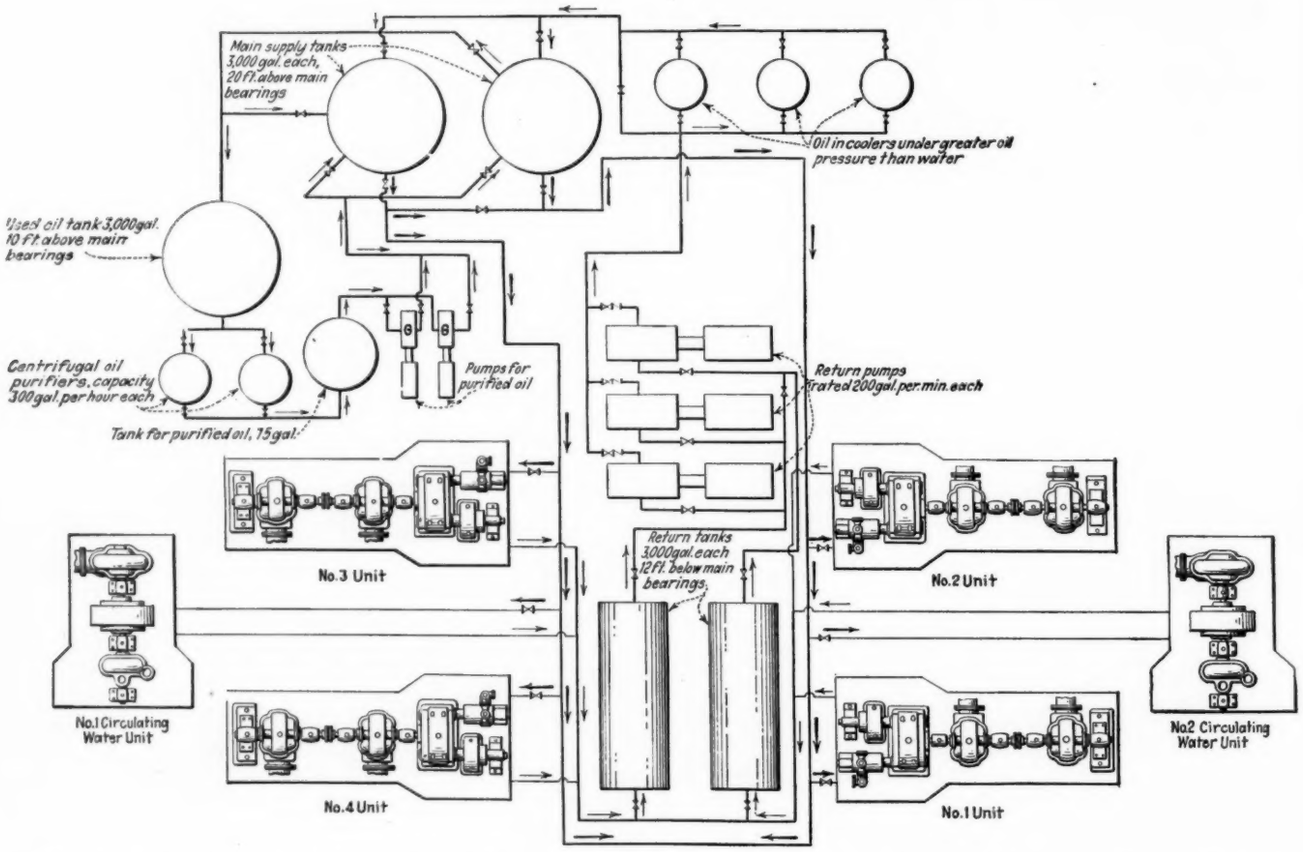

Main supply tanks 3,000 gal. each, 20 ft. above main bearings
Oil in coolers under greater oil pressure than water
Used oil tank 3,000 gal. 10 ft. above main bearings
Centrifugal oil purifiers, capacity 300 gal. per hour each
Pumps for purified oil
Tank for purified oil, 15 gal.
Return pumps rated 200 gal. per min. each
Return tanks 3,000 gal. each 12 ft. below main bearings
No. 3 Unit
No. 2 Unit
No. 1 Circulating Water Unit
No. 2 Circulating Water Unit
No. 4 Unit
No. 1 Unit

Fig. 2—Return oil is cooled to 100 deg. F. and delivered to main supply tanks. Centrifugal purifiers with auxiliary apparatus recondition the oil

at an excessively low elevation. Single-acting 8x12x12 reciprocating pumps with a capacity of 200 gal. each, handle the return oil, being controlled by a balanced valve and float mechanism.

Spiral-flow oil coolers are arranged with such a capacity as to maintain the proper working temperatures when two coolers are in operation. The pressure of the oil in these coolers is somewhat greater than that of the water in a cooling coil. A leak in the cooling coils therefore would not introduce water. A twin-type strainer is provided for removing foreign matter from the untreated river water which is used for cooling.

The two centrifugal purifiers of 300-gal. capacity of oil per hour each are simply a modified design of cream separators. They remove all trace of foreign matter as well as water. In connection with these purifiers the used-oil tank which supplies them is fitted with a steam coil for bringing the oil to the proper temperature naturally carried through the contact area by the movement of these elements.

The operation of the system is quite simple. Oil from one of the supply tanks flows through supply lines to all bearings and gears of units in operation and, after passing from these bearings and gears, flows through drain lines to one of the return tanks. The supply of oil to bearings and its removal are by gravity. The automatically controlled return pumps force the oil from the return tank through the coolers to the supply tank from which it started.

Used oil is replaced by fresh oil in a novel and effective manner. When the oil in circulation from this first supply tank shows any signs of deterioration from foreign matter, water or other cause, the valve from the second supply tank is immediately opened, that from the first closed and the return pump speeded up to draw the oil all out of this return tank. After the

supply and drain lines are well flushed out with the new oil, the valves are operated to drain to the second tank and pump the return oil to the second supply tank.

The contents of the first supply tank are now drawn off into the used-oil tank and brought to correct temperature for purification by means of the steam coil.

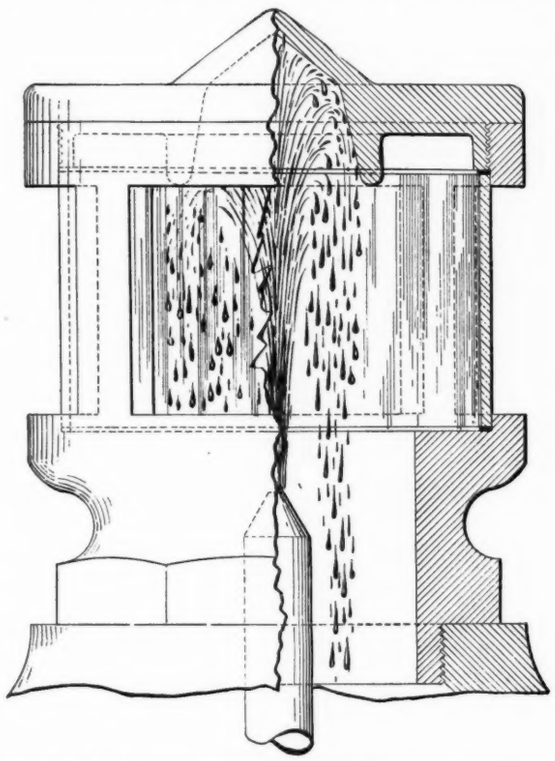


Fig. 3—Discharge from nozzle indicates oil pressure

The oil is then run through the centrifugal purifier and pumped back to the supply tank from which it came and there held in reserve until it is desired to purify the alternate supply.

Temperatures are practically uniform in the circulating system from coolers to supply tank and from supply tank to bearings. The temperature, of course, rises as the oil passes through bearings and then remains practically constant until it passes the coolers, where there is a drop of about 12 deg., which is practically the same as the rise in the bearings. The temperature of oil to bearings varies from about 100 deg. to 130 deg., the latter temperature being that found in summer when cooling water becomes very warm.

Oil pressure is practically constant, since it is controlled by the elevation of the supply tank, in which practically a constant level is maintained. Velocities in the main supply lines vary from 3½ ft. per second with two main units in operation to 6½ with four main units in operation. The normal design load calls for three units in operation and the velocity of about five feet per second. Drain lines are larger, and a velocity of a little over three feet per second is obtained.

In actual practice the system works out so well and local conditions have been so favorable that in about three years of operation the oil supply has never reached a point where appearance or the common test with a 50 per cent gasoline mixture indicated water or foreign matter.

Alternate tanks are kept in operation for about six weeks and the oil is then purified. About two quarts of water and less than a teaspoonful of foreign matter are taken out each time. The addition of oil with three main units in operation amounts to about three quarts a day. The lubricant used has a specific gravity of 26 to 31 Bé. and a viscosity by the Saybolt test at 100 deg. F. of 270 seconds.

Settling in the tanks is not an essential part of the system operation, though, of course, when oil is standing in the supply tank waiting to be purified or in the used-oil tank, it has opportunity for settlement. The quantity used per year, with three main units in operation part of the time and two the remainder of the time, is about 275 gal., or about 5 per cent of the complete system.

Main Points of Design of the Lubricating System

1. Oil is supplied at practically uniform pressure by means of overhead tanks.
2. An oil supply for fifteen minutes of operation is independent of the return oil pump.
3. Warnings are provided for failure of a return oil pump, so that another unit may be placed in operation in ample time to prevent a shutdown. Signals indicate whether the supply tanks exceed minimum or maximum oil levels, and indicators show oil levels in these tanks.
4. The large amount of oil in a system tends to dilute any water or other impurities that may get into it, so that the effect is not serious and, ordinarily, will not affect operation until the regular purifying period.
5. The oil coolers are designed for greater pressure of the oil than that of the water in the cooling coils. Leaks, therefore, will not result in water getting into the system.
6. The return oil pumps operate at a very low speed, one unit being sufficient, with two for reserve.
7. The installation of duplicate reserve tanks allows one for ordinary operation while the second may be repaired or cleaned if desired.
8. The supply and drain piping is so arranged that in case of the introduction of foreign matter, it is possible to flush out with kerosene, or other cleaning agents, without the necessity of shutting down.
9. It is possible to purify an amount of oil equal to that necessary for supplying the entire station, at one operation, since there are two gravity reserve tanks and one of them may be cut off from the system while its contents are reconditioned by means of purifying equipment. This is more effective than when a small quantity of oil is continuously purified from the viewpoint that it is possible thus to eliminate practically all impurities in one operation, while otherwise it would be necessary to dilute the bad oil with the good oil.

A carbonizing device has recently been completed by the Bureau of Mines for utilizing the lignite deposits of the Northwest through the manufacture of char. The total area of lignite deposits of Montana, North and South Dakota and Texas are large and their true economic value is seldom realized. The lignite lands of North Dakota alone are estimated at 32,000 square miles. Ninety per cent of the country's lignite resources lie in the Northwest. As the areas adjacent to lignite deposits are not industrially developed, the manufacture of gas and byproducts generally is not looked upon as an advantage in the commercial utilization of lignite.

The First World Power Conference —Boilers and Turbines

Latest Practices in Steam Generation and Use—High-Pressure Boilers and Turbines Receive Special Attention

THE opening sessions of the World Power Conference at Wembley, England, as covered in the July 29 issue, dealt largely with the world's power resources and their economic aspects. In addition the Thursday morning (July 3) session dealing with steam generation was reported. This subject was continued in the afternoon meeting at which A. F. Enström (Sweden), Direktor, Kungl-Ingeniörsvetenskapsakademein, presided. The session was given over to the discussion of the following papers: "Steam Generation," by Sir James Kemnal (Great Britain); "Recent Practice in Steam Generation in the United States," by D. S. Jacobus (U. S. A.); "The Use of Steam at High Pressures and High Temperatures in Central Stations," by W. F. Monroe (U. S. A.); "Steam Generation at Extra High Pressures," by Viktor Blomquist (Sweden); "The Influence of High-Pressure Steam on the Design and Economy of Large Steam Boiler Plant," by Dr. Friedrich Münzinger (Germany); "High-Pressure Steam, its Present and Future Application in Power and Heating Plants," by O. H. Hartmann (Germany).

Considers Fifteen Hundred Pounds Practicable Steam Pressure

In his paper Sir James Kemnal claimed that experience with pressures of 500 lb. warranted incurring the extra capital cost involved in pressures up to 1,500 lb. and temperatures of 750 deg. F. or higher. With a boiler efficiency of 84 per cent, and 1,500 lb. pressure, the over-all efficiency from coal to electricity would be in the neighborhood of 30 per cent close to that of large Diesel engines. The boiler installation would include a reheater, water economizer and air heater. The author described an 800-lb. installation being erected by the Electricity Works of Flanders at Langerbrugge, in which the steam, after passing through turbines at this pressure, will be exhausted at 300 lb. into turbines that exist already for the service of the station. For pressures above 900 lb. the steam and water drums should be seamless, and probably a number of small ones on each boiler should be substituted for the large ones. He stated that very high pressures required the use of a deaërator.

The paper of Dr. Jacobus is not available at this writing. A long abstract of W. S. Monroe's paper on "High Pressures and High Temperatures in Central Stations" appeared in the July 15 issue.

Viktor Blomquist's paper on "Steam Generation at Extra High Pressures," which will be abstracted in a later issue, pointed out the gain to be obtained by going to higher pressures, and showed that this gain is proportionately much greater with high back pressures than with turbines operating at a good vacuum. Thus there is more to be gained by high pressures in the isolated plant than in the central station.

In his paper on "The Influence of High-Pressure Steam on the Design and Economy of Large Steam Boiler Plants, Friedrich Münzingef stated that the greatest difficulty in connection with high pressures lay in the construction of the boilers. There has recently been an immense amount of research work in Germany on the properties of boiler plate and the influence of the manufacturing process on the durability of boilers. Investigation has shown that the strength of plates is less at the edges than toward the middle. Thus in making riveted drums, the rivet seams are made along the weakest part of the plate. Excessive riveting pressures are the source of much trouble. This difficulty, as well as those due to manufacturing strains and operating stresses, becomes more serious as the steam pressure increases.

Remarkable progress in the design of high-pressure boilers has been made by the production of special steels containing from 3 to 5 per cent of nickel at the Krupp Iron Works. Drums made of nickel steel and forged with the end plates in one piece without seams are most suitable for the very high steam pressures and correspondingly high temperatures. Such drums are naturally expensive. The number and diameter of boiler drums will evidently have to be reduced to lower the price of high-pressure boilers. The extent to which this is practicable will depend upon the sensitiveness of the combustion control.

Novel Suggestion To Reduce Cost of High-Pressure Boilers

To secure the advantage of the low cost of high-pressure sectional boilers with their small drums and correspondingly small steam space, they may be supplemented by a steam accumulator placed between the high-pressure and low-pressure stages of the turbine. The accumulator acts as supplementary water capacity for the drum. Not only is the accumulator built for lower pressures than the boiler drum, but the storage capacity of one cubic foot of water (at saturation temperature) at 210 lb. is about six times as high as at 1,400 lb. The economical use of high-pressure steam in stations with high load peaks can probably only be made possible by the insertion of accumulators.

Dr. Münzinger concluded his paper with the statement that the electric-power station of the future would show the following characteristics: Steam pressure, 570 to 1,400 lb.; boilers with a small water capacity; extensive use of feed-water heating by bled steam; steam accumulators in the low-pressure range; reheating of the steam; puverized fuel and air heaters. Making full allowance for capital cost, the saving should be from 10 to 20 per cent for a steam pressure of 1,400 lb., as compared with 220 lb.

The paper of O. H. Hartmann, on High-Pressure Steam, is not at present available.

The discussion on these papers was started by Mr. Tansley. In reference to Sir James Kemnal's paper, he thought that a booster pump on an economizer is

less cumbersome than deaërating, the economizer being staged and the air expelled between the stages.

David Brownlie referred to the Benson process of making steam at the critical temperature, where the boiler proper, the function of which is ordinarily to supply the latent heat, would have no latent heat to supply. Powdered coal, he said, had prodded the stoker men and helped to improve the efficiency of the stoker. There are 30,000,000 tons of coal used annually for low-temperature processes that could be made to produce power at almost no cost by generating the steam at high pressure and utilizing its temperature fall for power and its heat rejection, or exhaust, for the low-temperature processes.

C. F. Wade emphasized the desirability of increasing the efficiency of the boiler and suggested paying some attention to the advantage of increasing the velocity of the gases as indicated by Professor Nicholson's experiment.

Mr. Orrok said that we had got pretty nearly to the limit in efficiency in the generation of steam (92 per cent on test, 80 per cent over long periods and 78 on the year's run). Most of the water-tube boilers speed up their gases at the end of the first pass. The velocity through the economizers is slowed down.

W. H. Patchell said that he was responsible 20 years ago for the first big boiler at Bow Station. He was looking for combustion space. The practice then was to put the first header 6 ft. from the floor; now it is 15 or 20 ft. Personally, he is afraid of nickel-steel. He spoke of the 1,200-lb. boiler at Weymouth, Mass., where the drum is 4 in. thick and made like a seamless tube without welded or riveted joints. High pressure is pretty on paper, but he did not like to think of 400 lb. pressure on the final joint of the initial turbine. He said that the two-stage economizer mentioned by Mr. Tansley did not do away with the necessity of deaërating.

Using Economizer To Protect Boiler

E. Kilburn Scott, of Vickers & International Combustion Engineering, spoke of the use of insulating bricks. For firing bituminous coal in pulverized form his firm requires 90 per cent to pass a 100 mesh and all through a 40 mesh. With anthracite 80 per cent should pass through 200 mesh and all through a 60 mesh if the fuel has one per cent free moisture.

Mr. Chandler spoke of the effect of an economizer on the durability of a boiler. They had a battery of twelve 4,000-sq.ft. B. & W. boilers in operation 24 years, run with economizers. At their other plant, run without economizers, the boilers deteriorated much faster. The makeup water deposited the bulk of its impurities in the economizer instead of letting them go into the boiler. He did not agree with the statement that 60 per cent of the work was done in the first row of tubes. If it were so, why not make a wide, low boiler with few rows? The upper rows do the work. On a boiler 14 rows and 14 high the scale deposited in the top row of tubes was only 24 per cent less than in the lower row.

Prof. Henry J. Spooner spoke of the work of Jacob Perkins. In 1830 he had a boiler that had been working in the neighborhood of 450 lb. They took out some of the tubes after a considerable period of service and found them in excellent condition. In the 1870's he had numerous tugboat engines running at 450 lb. A wealthy man ordered a triple-expansion engine for his yacht, to be run at 500 lb. It was built and installed, but some little delay or mishap caused him to order it scrapped.

Discussing his steam-mercury plant, W. L. R. Emmet (U. S. A.) said that the process consisted fundamentally of vaporizing mercury in boilers, carrying it to a turbine that operates like a steam turbine, the exhaust being used to generate steam. The mercury runs back to the boiler by gravity, but is carried through a heater on its way. From the thermodynamic viewpoint mercury is a very favorable fluid, since its Rankine efficiency approaches that of the Carnot cycle. At present the plant is operated with a mercury vapor pressure of 50 lb. absolute. Higher pressures are contemplated. The present plant is designed for 1,800 kw., but not over 1,500 has been developed, on account of leaks at high loads. A new boiler of more practicable form has been developed. This has been run at 100 lb. gage. The new boiler at Hartford will carry 70 lb. gage. The mercury does not wet the tubes. Everything in the present plant is satisfactory except the boiler. The production of steam from mercury is simple. The globules of condensing mercury form on the tubes and fall off. The vacuum is 29½ in. with 7 deg. temperature difference. So far no mercury has been lost. For high temperatures the boiler steel should be protected by calorization. Otherwise a special steel must be used. The mercury boiler for power stations is also applicable to ship drive, where half the present fuel can be saved.

In reference to Mr. Emmet's paper Mr. Ferguson said that the present mercury system was run on a commercial schedule. It was no longer experimental, and there were no fundamental difficulties. The General Electric Co., he said, was preparing to put the system on the market soon, with a guarantee.

In reply to a question as to the possibility of a rise in the cost of mercury, Mr. Emmet said that at present he could get all he wanted. A large demand might lead to the working of the poor ores and a price of from $2 to $3 a pound.

Dr. Jacobus said that at the inception of the steam turbine there was just as much skepticism as there is now on the mercury turbine. Mr. Emmet, he said, was an optimist, but one who had to his credit the design of a turbine and the electric drive for ships. Mr. Sanderson called attention to the fact that the mercury system uses high temperature with low pressure, instead of high temperature with high pressure as in other systems.

Turbines Discussed in Steam-Utilization Session

THE session on steam utilization on Friday morning, July 4, was presided over by John W. Lieb, vice-president, New York Edison Co., the subjects considered being the following papers: "Steam Turbines," by Sir Charles A. Parsons (Great Britain); "Steam turbines for High Pressures," by Ir. C. F. Stork (Holland); "Extra High Pressure Steam Turbines," by V. Nordström (Sweden); "Steam Turbines and Condensing Equipment," by Francis Hodgkinson (U. S. A.).

In presenting the subject Mr. Lieb said that the steam turbine had brought about an intensive study of thermodynamics. He touched upon power-plant efficiency versus unit efficiency. The reciprocating engine is admirable for its flexibility and its ability to start

up quickly, but is doomed by the high price of real estate. The finest kind of compound and triple-expansion engines have been scrapped at a price which would hardly pay for their removal after no more service than got them into good running condition—a striking instance of the obsolescence that goes with a rapidly developing industry.

The steam turbine, he said, demanded the best of material and the finest of work and design skill in avoiding nodes, etc. Any turbine must conform to the requirement of reliability in service. Power has become such an integral part of our daily life that dependability in its supply is not second even to efficiency. Units are built in capacities of 30, 50, 60 and maybe 100 thousand kilowatts, and the demand for such equipment is so great that placing orders for three or four such units at a time is not unusual.

Sir Charles Parsons, in presenting his paper, said that before 1884 there were already 100 patents in the patent office on steam turbines. Nearly all the principles used today were enumerated, but not in the right proportion. He spoke in a complimentary way of De Laval for his exposition of the expanding nozzle and the reducing gear and Curtis for his use of the velocity stage.

Parsons Suggests Compromise Turbine Design

The question has arisen, he said, as to whether a compromise between the so-called "impulse" and "reaction" principles might not give a higher efficiency than either alone. The builders of the two types seem to be approaching this question from opposite standpoints. There seems to be no reason why pressures of 2,000 lb. per sq.in. would not be practicable in a large steam-turbine installation. In such a case there may be a small auxiliary high-pressure turbine having several stages of small diameter and exhausting into the turbines working at ordinary pressures. Any effort to extend the steam cycle by lowering the temperature of condensation must overcome the space limitations in the last stages. One of the best solutions is to provide a separate low-speed turbine of large diameter for the final stages of the expansion.

The 50,000-kw. (normal capacity) units[1] now nearing completion at Newcastle-on-Tyne for the Crawford Ave. Power Station of Chicago has three cylinders in series on the steam flow.

With 550-lb. steam pressure and 750-deg. temperature at the throttle, 700-deg. reheat temperature, 29.25-in. vacuum and stage heating, a thermal overall efficiency of 33 per cent from steam to electricity is anticipated.

High-Pressure Turbines Not Necessarily Inefficient

The second turbine paper, "Steam Turbines for High Pressures," by Ir. C. F. Stork, was presented by Ir. J. Strumphler, works engineer for Gebr. Stork & Co., who told why the Stork company adopted the Erste-Brünner machine instead of the Zoelly machine that they had been building. Extremely good efficiencies obtained in Stodola's test of the turbine at the Nestomitz sugar mill (about 83 per cent Rankine efficiency).

The paper stated that there was no necessity for lower efficiency in the high-pressure section of a turbine. Governing by cutting out nozzles does not lead to good economy at partial load. Low steam velocities in the high-pressure section are essential. A 16,000-kw. turbine under construction has a guaranteed steam consumption of 8.44 lb. per kilowatt-hour, using steam at 500 lb. and 750 deg.

V. Nordström, in his paper on "Extra High-Pressure Steam Turbines," told of the practice of the De Laval Works in Stockholm, Sweden. The correct speed for a turbine wheel, from the point of view of fluid friction losses, should increase about as the square root of the pressure. That is, if 3,000 r.p.m. were suitable for 150 lb., 9,500 would give the same loss at 1,500 lb. This is for the same heat drop per stage; higher heat drops per stage at the higher pressures naturally require still higher speeds. The solution of this difficulty is to connect high- and low-pressure turbines by spur gearing which has an efficiency of 98 per cent and up. When properly made, the reliability of gear drive is beyond dispute. The small size of high-pressure turbines makes it a simple matter to handle fairly high temperatures.

In his paper on "Steam Turbines,"[2] Francis Hodgkinson (Westinghouse Electric & Manufacturing Co.) predicted that compounding would be adhered to for turbines above 50,000 kw. To keep down losses impulse nozzles should occupy a large part of the circumference. Results obtained from experiments with stationary blades should be applied with caution to turbine design. An important design constant with a direct relation to the efficiency of impulse blading is the ratio of the steam path thickness between the blades to the radius of curvature of the concave side. The minimum total loss occurs with a fairly small value of this ratio; that is, with rather wide blades. Incidentally, corrosion is less serious with this form of blade. Mr. Hodgkinson said that evolution of General Electric Co. turbines had been toward a large number of single-velocity (Rateau stages) with one two-row (Curtis) stage at the high-pressure end in certain cases. A description was given of the Westinghouse turbine recently installed in the Hudson Avenue Station of the Brooklyn Edison Co. In the newer designs of Westinghouse turbines, he said, the bleeder connections are designed to remove part of the moisture along with the steam. A 50,000-kw. three-cylinder unit being built for the Crawford Avenue Station of the Commonwealth Edison Co. reheats the steam at 132 lb. abs. For reheating to pay, the pressure drop through reheater and piping must be kept to a minimum. Ten pounds drop is expected at Crawford Avenue.

Junggren Discusses Hodgkinson's Paper

In a written discussion aimed to supplement Mr. Hodgkinson's paper, which dealt mainly with Westinghouse practice, O. Junggren gave further information on turbine development of the General Electric Co. They have installed or on order over 3,000,000 kw. (in sizes of 10,000 kw. and larger) of horizontal machines with one combined velocity stage and several single wheels.

Of turbines with single wheels throughout and conical rotors, over 4,000,000 kw. are installed or on order (sizes, 15,000 kw. and over). This type of turbine was put on the market in 1915. There are now fifty 30,000-kw. units of this type in actual service with nineteen more on order. This type of machine is made up to 50,000 kw. The underlying idea in the development of these units has been reliability through simplicity.

The average total production of electricity by public-

[1] Turbine was described in the July 15 issue.

[2] An abstract will appear in an early issue.

utility power plants in February, 1924, reached the large figure of 168,300,000 kw.-hr. per day, of which 114,000,000 was produced by fuel. There is little room for increasing the efficiency of the turbine itself. The greatest advancement will be found in increasing the steam pressure and temperature in conjunction with bleeder heating and steam reheating.

At the present time the General Electric Co. has built or on order 460,000 kw. of turbines to operate at from 530 lb. to 600 lb., 725 deg. steam temperature and reheat temperature, the reheat pressure being about 110 lb.

More skill than formerly is required to operate the modern plant. At an early date the combustion engineer will replace the fireman.

Mr. Junggren pointed out that turbine buckets rarely fail from centrifugal force alone. If vibration and heat stresses can be avoided, we may safely produce comparatively long buckets. The subject of vibration is very important. Speed by itself is not an important factor in safety. In the near future we may see large turbine units operating on pressures as high as 1,500 lb. in as satisfactory manner as present-day units.

S. Z. de Ferranti said that in 1902 and 1903 he came to the conclusion that the right thing to do was to build a reheating turbine, to get as nearly as possible isothermal expansion. In the heat engine the great thing is not only the high temperature dropping to the low temperature, but that you should have a cycle in which you do as much of the work as possible at the top temperature.

Early Reheating Experiments

About 1910 he built a turbine of 3,000 kw. running at 3,000 r.p.m. The blading was on the Parsons system and there was no dummy. The machine was provided with a regenerator between the exhaust and condenser, and was later fitted with an arrangement for bleeding in four stages. He used an outer casing of wrought steel and another into which the stationary blades were welded. The running drum also had the blades welded in. Its performance was generally satisfactory. He superheated the steam regularly and without any undue difficulty to 750 deg. F. and exhausted the steam still superheated, reheating it in separately fired superheaters. He thought he should have to use an alloy steel for the reheaters, but had great difficulty in obtaining the tubes and found afterward that he could use ordinary steel for that temperature. The alloy steel gave trouble in working, but he found that drawing it was greatly facilitated by coating the steel with copper before putting it through the dies. The economy was greatly in advance of anything that was being done at that time. He hopes at some time to collect the drawings, photographs and test results for record and publication. Four years ago he came back to this same idea of doing the positive work at the highest temperature and the work of compression or negative work at the lowest possible temperature. He built a 10-in. engine and ran it at a temperature of 900 deg.

Sir Charles Parsons said that in his opinion the reason that Mr. Ferranti's idea would not go through was the disposition of cast iron to grow and change shape at such temperatures.

Mr. Bauman, of Metropolitan Vickers, told of tests made of a 7,000-kw. turbine installed at Bristol with and without the multiple exhaust. With the multi-system it was able to use to advantage a 28-in. vacuum as against 27-in. without it. An extra high-pressure cylinder is necessary for the utilization of high-pressure steam.

Mr. Pocobradski, of Fraser & Chalmers, Inc., discussed the new law governing steam flow. The efficiency is highest at very low velocities, while we have to deal with velocities of from 300 to 1,500 ft. per second. These results suggest new lines of design. Only very low and very high velocities, no intermediate, should be used, the high-pressure turbine with a small number of stages, the low-pressure with a large number. He described a design wherein an internal casing floats on an external casing and remains coaxial. Between these casings the steam pressure is held at some moderate figure so that the effect of the high pressure is taken up by the two casings and the external casing kept cool by having a flow of steam against it.

Mr. Koenig, of the English Electric Co., said that the ideal expansion line for a steam turbine would be parallel to the saturation line of the steam. Turbines are defective in respect to Mr. Stork's "quality figure" so far as the turbine's low-pressure part is concerned.

The designers of turbines having had their say, the chairman called upon George A. Orrok to speak for the consulting engineers. It appears, he said, that the number of stages has little to do with the efficiency. We have turbines with 8 stages that are very efficient and turbines with 80 stages that are just about as efficient and between the two limits a wide sweep of relative efficiencies running about the same. Variations in the design cut no figure in the guarantees. What the central-station man wants is a turbine that will run 8,760 hours in the year and that can be started up from cold in two minutes, and the blades of which will not deteriorate.

S. J. Watson, speaking for the turbine users, said that the third consideration was cost. With more casing to a machine you can get an improvement in economy; but how much does it cost? Which is the better, two 20,000-kw. machines, each with its own casing, or one 50,000 consisting of three or four casings?

Advantages of Twelve-Hundred-Pound Boiler at Weymouth

I. E. Moultrop, of the Boston Edison Co., told of the 1,200-lb. installation being put in by his company at Weymouth, Mass. A very efficient installation may be less economical than something simpler. A 530-lb. reheating design does not fit their conditions where the night and Sunday load is very light, but a simple station with a high-pressure unit superimposed does. One gets no extra capacity for the money spent for greater efficiency, but by superimposing a high-pressure unit they get increased efficiency and capacity too, and the unit cost will be about the same.

Bernard Price, of South Africa, considered efficiency from the point of view of fuel cost. The cost of maintenance, too, may be no small factor and is very important when the plant is installed far from the maker of the equipment.

Mr. Cook, associated with Sir Charles Parsons, said that we had been extravagant in the use of energy, coal and oil, but were now becoming keenly alive to the situation. Replying to Mr. Pocobradski, he said that the internal cylinder is not necessary provided the turbine is made small enough, which, of course, implies using a high rotative speed.

Modern Equipment Reduces Cost of Power

Steam Equipment of the Abbeville, La., Municipal Light Plant Replaced by Diesels—Cost of Generating Current Reduced—Water Works Served by Motor Driven Centrifugal Pumps and An Air Lift

THERE is, usually, a notorious difference between electric rates in large cities and those in towns under 25,000. Since the small plants are in the main municipal undertakings, these excessive rates are often used as an argument against municipal ownership, although the high production costs cannot be charged justly to poor management, but are traceable in most cases to inefficient machinery. Fortunately, some municipalities are keeping pace with the advance in power engineering and, by replacing worn out or inefficient machines, are able to sell current at rates as low as those prevailing in the larger cities.

In 1906 Abbeville, La., installed a steam plant which gave satisfactory service although the operating costs were high. As a partial relief a 100-hp. horizontal oil engine was installed in 1914. This was operated in conjunction with the steam plant until 1919, when the steam engine was discarded and a 75-hp. semi-Diesel oil engine installed. While costs were lower than when the steam plant was operated, conditions were bad. The streets were without lights owing to insufficient generating capacity; the water-pumping equipment was inadequate and the city was being heavily penalized by the fire insurance companies; no new business could be attracted to the town, for the power rate was too high. In addition, the water and light department faced a deficit each month.

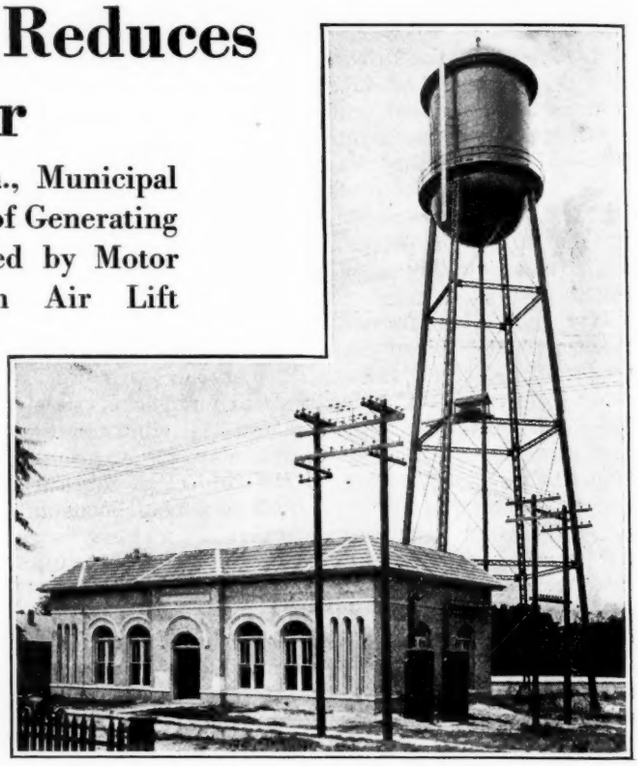


Fig. 2—Remodeled power plant

The decision was made to build a new plant equipped with modern equipment, and to this end a bond issue of $125,000 was authorized. The old power house, which was of brick construction, was remodeled to accommodate the new equipment. The roof was raised to give additional headroom, and the brick walls were covered with stucco, giving a pleasing effect.

The authorities decided upon Diesel engines as prime movers, and three 175-hp. units, each direct connected to 150-kva. alternators with direct-connected exciters, were installed. Each engine is equipped with a governor-control motor which permits synchronizing the units from the switchboard and provided with the usual oil pump, circulating-water and exhaust lines, along with two 12,000-gal. oil-storage tanks.

In addition to the generating equipment the city installed two 1,000-g.p.m. motor-driven Underwriters' fire pumps, two 300-g.p.m. motor-driven pumps for the ordinary pumping service and two 300-cu.ft. motor-driven air compressors to supply air to the deep-well air lifts. To guarantee a water supply for emergencies, a 500,000-gal. covered concrete reservoir was built in addition to the 75,000-gal. tower tank shown in Fig. 2.

A part of the bond issue was used to lay new water mains and fire hydrants. The old electrical distribution lines were direct current and these were changed to alternating.

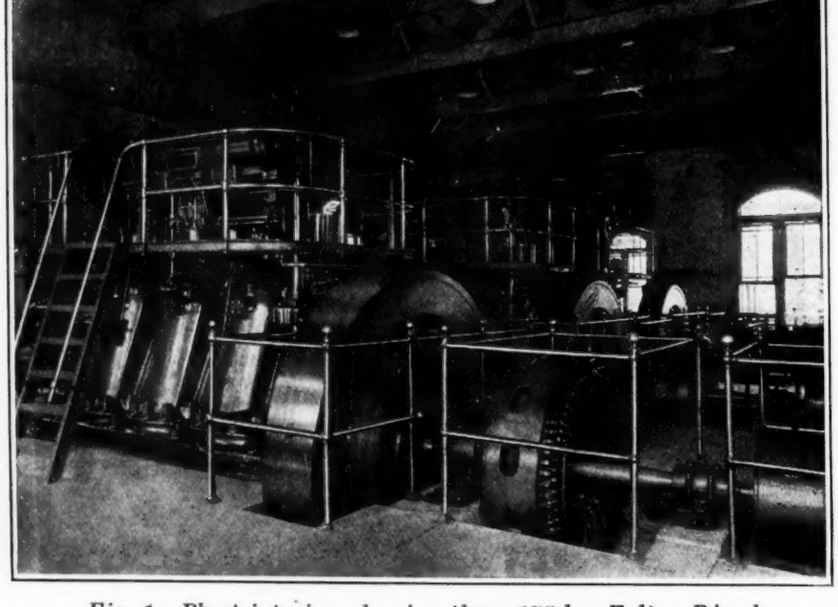


Fig. 1—Plant interior, showing three 175-hp. Fulton Diesels

To appreciate the effect of the new equipment one should compare the tables showing the operating costs of 1913 with the costs of the obsolete plant. The plant cost, including overhead, of 1.96 cents per kilowatt-hour is good considering the low load factor. Under normal conditions one of the engines runs 24 hours and a second 18 hours, while the third is idle. The engines are operated in rotation, each running two weeks full time, then two weeks part time, followed by two weeks of idle time. Since the compressors and pumps are cared for by the light plant engineers, 5 per cent of their time is charged to that service. The operating report contains an item of repairs amounting to $800. This does not represent an actual outlay, for there were no repairs, but is a yearly sum set aside to care for repairs; in other words maintenance is made a fixed charge in the same way as is depreciation.

TABLE I—COST OF OPERATION WITH DIESELS

Station equipment cost	$65,800
Kilowatt-hours produced	4,000
Depreciation (25 yr. life)	$2,632.00
Average interest, 6 per cent — $\frac{25}{25}\left(\frac{65{,}800 \times .06}{2}\right)$	2,052.96
Repair reserve	800.00
Fuel oil, 87,600 gal. at 5 cents	4,380.00
Lubricating oil (456 gal.)	173.28
Labor (95 per cent of payroll)	6,498.00
Miscellaneous expense	120.00
Water	300.00
Total year cost	$16,956.24
Cost per kw.-hr., cents	1.96

In figuring depreciation in the old plant equipment, the discarded units have been credited with their second-hand values, while the depreciation has been taken as the average for the life of the engines, nine years in one case and four years in the other.

TABLE II—PLANT OPERATION BEFORE REPLACEMENT BY DIESELS

Depreciation on one engine ($7,400 ÷ 9)	$822.22
Depreciation on second engine ($3,500 ÷ 4)	875.00
Depreciation on building ($4,000 ÷ 9)	444.44
Average interest on above items at 6 per cent	709.25
Fuel oil, 85,410 gal.	4,270.50
Lubricating oil, 7,300 gal.	2,774.00
Labor	4,674.00
Repairs	1,200.00
Miscellaneous expense	300.00
Water	300.00
Total	$16,369.41
Cost per kw.-hr., cents	3.25

The saving may be summarized as: Saving per kilowatt-hour, 1.29 cents; savings per year, $11,145.60; reduction in cost per kilowatt-hour, 40 per cent.

All of the potential advantages of the new plant have not been realized; for by an increase in the load the cost per kilowatt-hour will of course decrease.

Generator for Direct-Current Auxiliaries Driven by Main Unit

Three points may be brought up to favor the placing of a direct-current generator driven by the main unit, for the purpose of furnishing current for the turbine auxiliaries. Driving power, as obtained from the main unit, is more efficient than that from any other source; speed variation for the circulating and boiler-feed pumps is more conveniently obtained from direct than from alternating current, and auxiliaries thus supplied may be independent of troubles affecting the power supply for the remainder of the station auxiliaries. In effect these auxiliaries are driven by the main unit, representing simplicity, and in addition the fact that roller bearings have been utilized in a recent installation, suggests a completed picture of convenience and efficiency.

For reliability the direct-connected exciter has proved its value. With the addition of motor-driven auxiliaries there is a multiplication of equipment, with an increased risk of electrical trouble. Short-circuits may be aggravated in their effects from the stored energy inherent in a turbine field. While this may have a slight tendency to lessen the dependabilitiy of a single direct-connected generator, it does not represent any less risk than that entailed with a plan of utilizing a separate plant for the excitation and auxiliary current. The combination of the direct-connected auxiliary generator and a second source of direct current for use in emergencies and in starting the main unit, offers apparently a better solution than either the direct or separately driven auxiliary generator.

Use of Induction Motors

Speed regulation is not such an essential characteristic of auxiliaries where a continuous power supply is generally required, such as for coal or ash handling, circulating-water screens, sump pumps, etc. The maintenance of a squirrel-cage alternating-current motor is ordinarily somewhat less than that of a direct-current motor of similar capacity, and for this reason alternating current is advantageous. For such motors of low voltage, the efficiency of the main generator and a transformer is balanced against that of the direct-connected generator. If auxiliaries could be operated at the voltage as supplied by the main generator, efficiency would be expected as slightly better than that of a direct-current direct-driven machine.

Speed regulation, however, is an important item in the operation of other apparatus, such as forced- and induced-draft fans. It would appear that something could be gained by utilizing the direct-driven direct-current generator for supplying power for more motors. There would be a necessity for an auxiliary source of direct-current supply for use when the main units are shut down. For reliability this auxiliary generator should be operating at the same time that the main units are running. This would involve rotational losses and would further complicate the problem by introducing an alternative of delivering a load, instead of running light, which would be a condition of somewhat higher generating efficiency, for the separately driven generator.

Multiple Sources of Power

Reliability incident to multiple sources of power does not necessarily depend on separately driven generators. Where a number of prime movers are installed with direct-connected auxiliary generators, each would represent a potential source of power, so that either multiple operation of the direct-current direct-driven machines, or provisions for obtaining current from a neighboring unit, in case of trouble, would represent an added reliability perhaps equal to that of an additional outside source. A steam-driven direct-current generator, however, would represent a necessity in starting up, provided no prime movers originally were operating. It would seem, therefore, that the field of usefulness for the direct-connected auxiliary direct-current generator could be increased somewhat more without greater appreciable risk, and in many instances at a gain in efficiency, even if a geared connection to the main unit were necessary.

Reconnecting Direct-Current Machines —Change in Speed

Three Problems Worked Out Showing How To Figure a Winding for a Change in Speed of a Shunt, Compound and a Series Motor

By A. C. ROE
Repair Superintendent, Detroit Service Station, Westinghouse Electric & Manufacturing Company

IT IS sometimes desired to make a permanent change in the rated speed of a motor. This can be done in a number of ways, each method having its limitations depending upon the type and make of machine. When voltage changes are involved, it is frequently possible to meet the new conditions by regrouping the armature and field coils, since the voltages in common use are a multiple of 110, such as 220 and 550. The relation of 110 to 220 or 1 to 2 is that which exists between a four-pole lap and wave winding. That is, if a four-pole lap winding is good for 110 volts the same coil grouped into a wave winding will be good for 220 volts. When speed changes are involved, the possibility of regrouping the winding for the new condition is not so good as for a change in voltage, consequently a new winding is generally required.

A four-pole motor having a wave winding on the armature and operating at 300 r.p.m. can be connected lap to operate at 600 r.p.m. and develop twice the horsepower if the commutator and brushes have sufficient capacity to handle the 100 per cent increase in current. The reverse of this is true. A 600-r.p.m. four-pole motor with a lap winding on the armature can be connected wave to operate at 300 r.p.m., but will develop only one-half of the original horsepower and will require only one-half of the full-load current of the 600-r.p.m. machine. In this case the question of commutator and brush capacity does not have to be considered. Unless conditions similar to these are involved in a speed change, a new winding will generally be required. Where the change in the cross-section of the armature conductors can be made in proportion to the speed, the capacity of the motor will vary with the speed. That is, if the number of conductors in series on the armature is decreased by two, and the cross-section of the conductors doubled, the speed and also the horsepower will be doubled. In other words, the horsepower varies with the speed as obtained by changing the conductors in series on the armature.

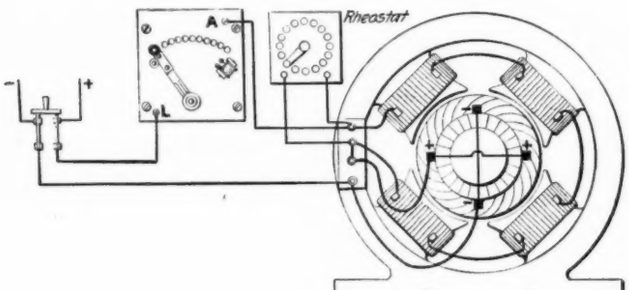


Fig. 1—Diagram of series motor with resistance in parallel with field coils for increasing the speed above normal

The speed of any direct-current motor can be changed by increasing or decreasing the field flux. One method of doing this in a series motor, is to put a resistance in parallel with the field circuit, as in Fig. 1. Cutting out this resistance will reduce the current through the field coils, thus weakening the field strength, and produce an increase in speed. Care must be taken, when using this method, not to cut out all the resistance unless the circuit is opened, or the field coils will be short-circuited. With a resistance in parallel with the field coils the speed can be increased only above normal value. To reduce the speed below normal, a resistance may be connected in series with the motor; this resistance is generally part of the starter. With a shunt motor the resistance is put in series with the field coils, as in Fig. 2. Weakening the field strength by cutting in the resistance will increase the speed above normal only, and strengthening the field by cutting out the resistance will reduce the speed to normal. Where the speed is to be reduced below normal, a resistance is connected in series with the armature, as in Fig. 3,

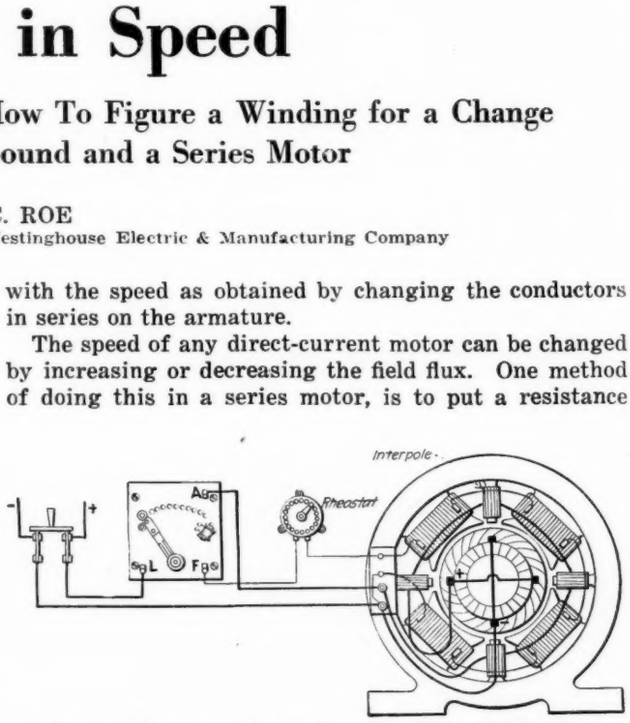


Fig. 2—Diagram of shunt motor with resistance in series with field coils for increasing the speed above normal

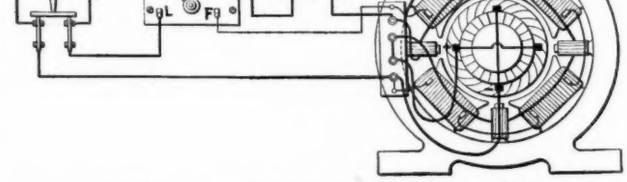


Fig. 3—Diagram of shunt motor with resistance in series with the armature for decreasing the speed below normal

which is usually part of the controller. These methods, as applied to motors designed for constant-speed service, cannot be depended on for an increase of speed above normal of more than about 15 to 25 per cent.

Another method of changing the speed of a series or shunt motor is to vary the air gap by adding or removing shims between the polepieces and the frame. Increasing the air gap will weaken the field strength and increase the speed. An approximate rule is that the air gap should be varied three to four times the desired per cent change in speed. For example, suppose it is desired to decrease the speed of a motor 10 per cent. Then the air gap would have to be decreased $3 \times 10 = 30$ per cent. If the original air gap was 0.2 in., the new gap would be $0.2 \times 0.70 = 0.14$ in. A change in speed of about 7 to 15 per cent can be obtained in this manner depending upon the degree of saturation of the magnetic circuit. If a greater range is desired, a combination of the resistance method and a change in the air gap can be resorted to if this does not interfere with the speed regulation.

Consider a 4-pole shunt motor rated at 7½ hp., 500 volts, 900 r.p.m. and 13½ amperes. Each field coil has 4,172 turns of one No. 23 s.-c.-c. wire. In the armature there are 47 slots, 94 coils and 93 bars, wave wound, with one dead coil. The pitch of the winding is 1 and 11, lead pitch 1 and 48, as in Fig. 4. Each coil contains 7 turns of one No. 14 d.-c.-c. The complete coil is made up of 2 coils wide by 7 turns deep. It is decided to increase the speed to 1,170 r.p.m., or an increase of $(1{,}170 - 900) \times 100 \div 900 = 30$ per cent. The new number of turns per coil equals $(7 \times 900) \div 1{,}170 = 5.4$ approximately. A fraction of a turn cannot be used, so that the new coils will have to be wound with 5 or 6 turns. If 5 turns are used, a speed of $(7 \times 900) \div 5 = 1{,}260$ r.p.m. will be obtained. If 6 turns per coil are used, then the speed will be $(7 \times 900) \div 6 = 1{,}050$ r.p.m. The only other course is to wind half of the coils with 5 turns and half with 6 turns, then tape a 6- and a 5-turn coil together so that they will be equally distributed around the winding. This is the equivalent of winding the coils with 5.5 turns. This arrangement will give a speed of $(900 \times 7) \div 5.5 = 1{,}145$ r.p.m., which is close enough for most practical purposes.

If the torque of the motor is to remain the same, the ampere-turns per coil must be kept constant. Since the original full-load current was 13.5 amperes, the current per path for a two-circuit winding is $13.5 \div 2 = 6.75$ amperes. Ampere-turns for the 7-turn coil was $7 \times 6.75 = 47.25$, and with an equivalent 5.5-turn coil the amperes per coil or path will have to be $47.25 \div 5.5 = 8.6$. The wire size in the coils should be increased in proportion to the current. One No. 14 as used in the original winding has a cross-sectional area of 4,106 circ.mils, then the new size equals $(4{,}106 \times 8.6) \div 6.75 = 5{,}231$, or one No. 13 d.-c.-c. wire may be used. This will increase the width of the coil 2 $(0.081 - 0.073) = 0.016$ in., which means that the 0.015-in. fish-paper cell used in winding the armature will have to be left out. If the horsepower rating does not have to be increased, the wire can be left the same size and the coils made up of 5 and 6 turns of one No. 14 wire and fillers used in the bottom of the slot. The horsepower rating with the increased size of wire would be $(7.5 \times 8.6) \div 6.75 = 9.4$. With the original size wire the rating should be 7½ hp., although the increase in speed results in better ventilation and the decrease in the armature resistance due to the reduction in the coil turns, should give the machine a slightly higher rating.

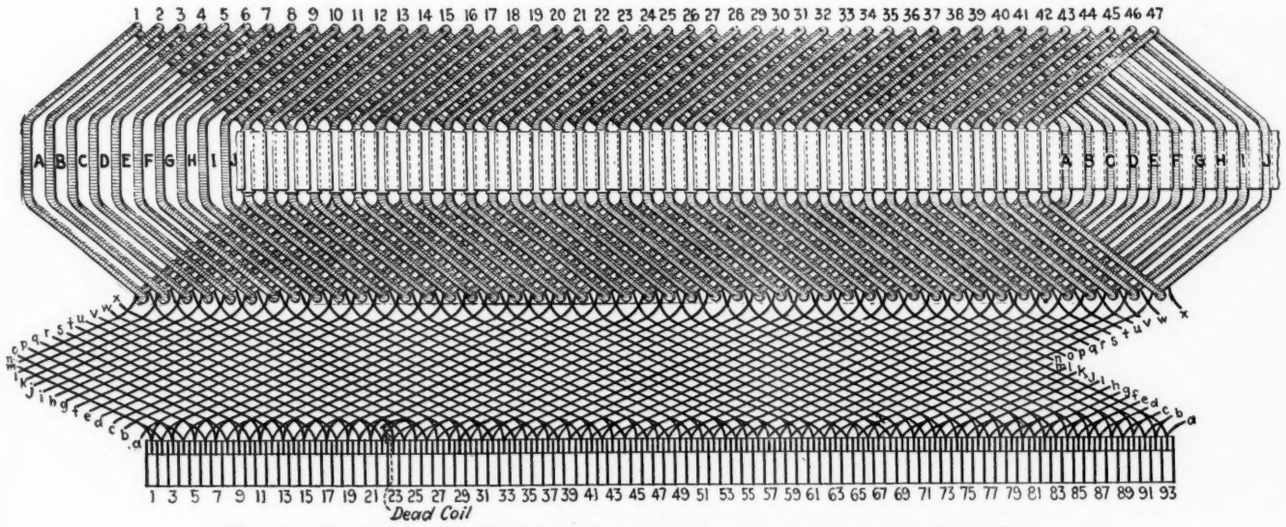


Fig. 4—Armature winding containing 47 double coils connected single-wave

If the motor had interpoles, it would be necessary to change the interpole windings. In the first case the ampere-turns have been maintained constant on the armature, but the current has been increased from 6.75 to 8.6 amperes. This current through the original interpole turns will give an excess ampere-turns on these poles. Before altering this part of the circuit, the machine should be tested with full load. If sparking or glowing of the brush tips occurs the commutating coil strength can be decreased by increasing the air gap, by means of an inductive shunt connected across the interpole circuit or by removing turns from the coils. In the second case the current flowing through the interpoles is the same as originally, but the armature ampere-turns have been decreased, therefore the interpoles will again have excess ampere-turns. The difference may not be great enough to warrant changing the interpole circuit, but if the strength of the interpoles has to be decreased it can be done as previously explained.

Next, consider a compound motor rated at 3½ hp.,

125 volts, 1,100 r.p.m. and 25 amperes. In the shunt-field winding each coil has 933 turns of one No. 17 s.-c.-c. wire, each series coil has 16 turns of one No. 7 d.-c.-c. wire, and the armature has 47 slots and coils, wave wound. Each armature coil has 4 turns of one No. 11 wire, coil pitch is 1 and 11 and the lead pitch 1 and 25, as in Fig. 5. It is desired to change this motor so as to operate at 1,600 r.p.m. The turns in the armature coils vary inversely as the speed, therefore the new turns $= (4 \times 1{,}100) \div 1{,}600 = 2.75$, or three turns will have to be used. This will give a new speed of $(4 \times 1{,}100) \div 3 = 1{,}466$ r.p.m. If this speed is not satisfactory, it may be increased by connecting a resistance in series with the shunt-field winding. To maintain the torque the same in both cases the ampere-turns must be the same. The 1,100-r.p.m. ampere-turns per coil equals $(25 \div 2) \times 4 = 50$. The current required for 50 ampere-turns with three turns per coil equals $50 \div 3 = 16.6$ amperes per armature circuit, which will require a larger size wire. One No. 11 wire has an area of 8,234 circ.mils, then $8{,}234 \div 12.5 = 659$ circ.mils per ampere. For 16.6 amperes the armature conductors should have $16.6 \times 659 = 10{,}939$ circ.-mils, or one No. 10 wire will be close enough to this size. The armature winding for 1,466 r.p.m. should therefore have three turns of one No. 10 d.-c.-c. wire, if this size wire can be used in the coils.

The full-load current has been changed from 25 to $16.6 \times 2 = 33.2$ amperes, which means that the series coils will require rewinding if the original compounding effect is to be maintained. The original 1,100-r.p.m. coils had $25 \times 16 = 400$ ampere-turns. Then the turns per coil for the 1,466-r.p.m. 33.2-ampere winding will be $400 \div 33.2 = 12$. The old coil had one No. 7 wire, which has an area of 20,816 circ. mils, or $20{,}816 \div 21 = 991$ circ. mils per ampere. Allowing the same amount of copper per ampere in the new winding, the series-field coil conductors will have $991 \times 33.2 = 32{,}901$ circ. mils cross-sectional area, or one No. 5 d.-c.-c. wire will be required. If the series-field coils will carry the new value of current without overheating, then all that need be done is to reduce the number of turns to 12, or in other words remove 4 turns from each coil. This, however, would probably not be found necessary and the same coils could be used in both cases. The shunt-field circuit need not be changed as it is across the line.

With a compound-wound motor having interpoles the commutating coils are in series with the armature and series-field coils and should be changed to give the same ampere-turns per pole as originally.

In the series motor the speed changes with the load, but will remain constant for any given load. The r.p.m. marked on the nameplate of a series motor is its full-load speed. The most satisfactory permanent change in speed of a series motor will require the proper proportioning of the turns to keep the magnetic and current densities the same, which in turn will tend to keep the characteristics of the motor the same at the new speed. If the increase required is not too great, the speed of a series motor can be changed by some of the methods suggested in the foregoing.

A 15-hp., 220-volt 4-pole series motor operating at 560 r.p.m. is to be changed to operate at 840 r.p.m.

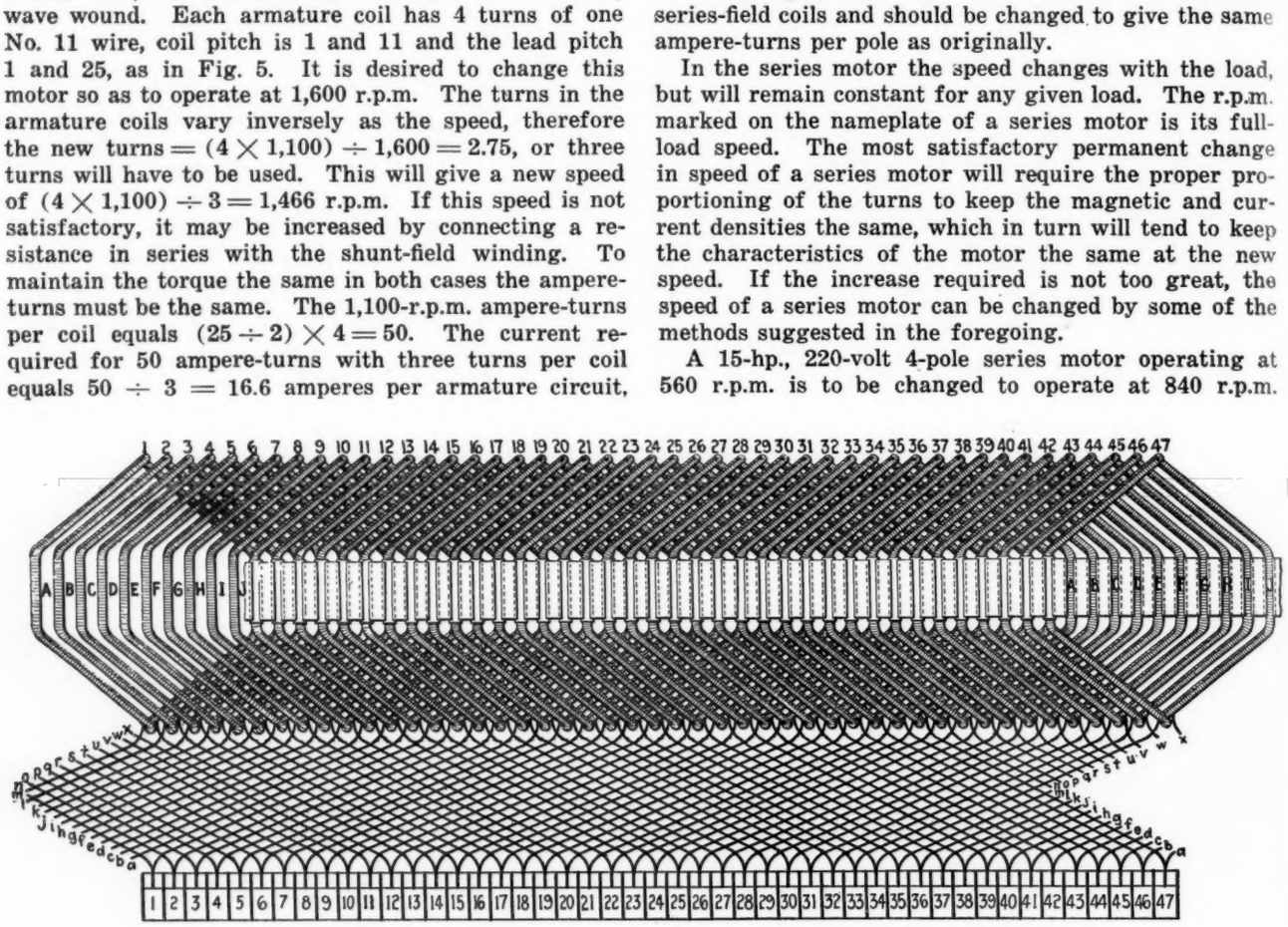


Fig. 5—Armature winding containing 47 single coils connected single-wave

Each field coil is wound with 52 turns of one No. 2 d.-c.-c. round wire made up in four layers of 13 turns per layer. The armature has 47 slots and 93 bars; each single coil is wound with three turns of two No. 12 d.-c.-c. wires in hand, the complete coil being 2 wide by 6 deep. The coils have a pitch of 1 and 11 and are connected to form a wave with a lead pitch of 1 and 48, as in Fig. 4. The turns of the armature coils must vary inversely as the speed. Therefore the new turns per coil equal $(3 \times 560) \div 840 = 2$. In the original winding the current was 58 amperes and since there were two circuits in the winding, the coils in each circuit took $58 \div 2 = 29$ amperes at full load. Then the armature ampere-turns per coil equaled $29 \times 3 = 87$. With two turns per coil the current per path would have to be, if the ampere-turns are to be maintained the same in both cases, $87 \div 2 = 43.5$, making the full-load current $43.5 \times 2 = 87$ amperes. The cross-sectional area of one No. 12 wire is 6,530 circ.mils, and two No. 12 wires will have a total area of $2 \times 6{,}530 = 13{,}060$ circ. mils. With 29 amperes per armature circuit the circular mils per ampere equal $13{,}060 \div 29 = 450$. With 43.5 amperes per path there will be required a total copper cross-section of $450 \times 43.5 = 19{,}575$ circ. mils. Three No. 12 wires will have a total cross-sectional area of $3 \times 6{,}530 = 19{,}590$ circ. mils. Therefore the new

coils may be wound with two turns of three No. 12 d.-c.-c. wires in hand, which will give a coil of $2 \times 3 = 6$ wires as in the original winding, but there will be six leads to each commutator bar instead of 4 as in the 560-r.p.m. winding.

The field circuit will also have to be rewound. The original turns per coil were 52 of one No. 2 round wire and with 58 amperes. The ampere-turns per coil were $52 \times 58 = 3{,}016$; then with 87 amperes the turns per coil will be $3{,}016 \div 87 = 34.67$, or 35 turns per coil will be satisfactory. A No. 2 round wire has a cross-sectional area of 66,370 circ.mils, and the new size wire will equal $(66{,}370 \div 58) \times 87 = 99{,}528$ circ.mils. A No. 0 round wire or a No. 1 square wire could be used, and the turns per layer and the number of layers arranged to suit the winding space. The horsepower rating at the increased speed will be $(840 \div 560) \times 15 = 22\frac{1}{2}$, provided the winding space will accommodate the new winding.

There are a few machines that have a compensating or pole-face winding in addition to the series and commutating coils. The winding is connected in series with the armature and carries full-line current. This winding's polarity is made opposite to that of the armature conductors under each pole, thus compensating for armature reaction. When making a speed change in a machine having a compensating pole-face winding, the ratio between armature and compensating ampere-turns per pole must be kept as close to the same value as possible.

When making a change in the winding of any machine, try to keep the magnetic density in all parts of the machine at the same value, which means that the ampere-turns must be kept constant if the characteristics of the machine are to remain the same. When decreasing the speed of any machine, the same procedure can be followed as outlined for an increase of speed, the turns per armature coil will increase and the current per path will decrease, hence a smaller size wire will be required and the output of the machine will decrease in direct proportion to the speed. Never increase the speed of any machine above a value that will give an armature peripheral speed higher than 5,000 ft. per min. or a commutator peripheral speed higher than 4,500 per minute.

Pneumatic Conveying of Pulverized Coal—Blow-Tank Method

BY I. G. COUTANT

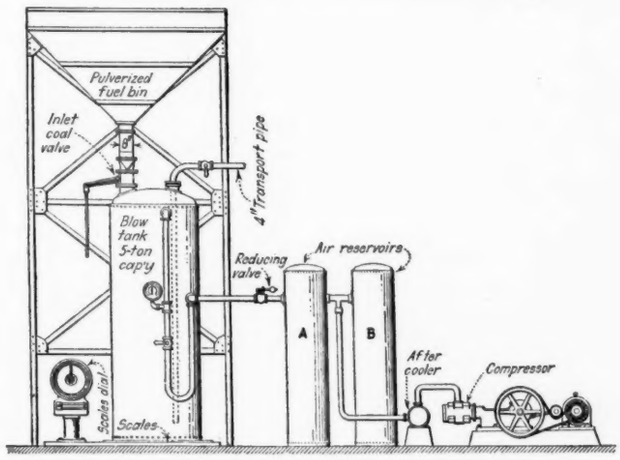
The blowing tank or reservoir has long been in use for the transportation of grain, sand, granular and powdered substances, and recently has found its application in connection with the conveying of pulverized coal.

Although in practical operation since 1915, little or no useful information has been given out concerning the application, operation and amount of air required. This holds true with the recent description of the Cahokia Station of the Union Electric Light & Power Co., published in the April 1 issue, in which brief mention only was made regarding the transportation of the fuel.

In this particular installation the coal drops by gravity from the collecting hopper to the blowing tank, from which it is transported to the bins above the boilers by compressed air at 50 lb. pressure through 4-in. pipes. The blowing tank is supported on scales, and the amount of coal is weighed before delivered to each storage bin.

Undoubtedly, the reason that little information has so far appeared on the operation of this system is due to the fact that few installations are so arranged that measurements can be taken.

The blowing tank and its principles offer practically a virgin field for the study of materials in suspension, transportation or flow, stored energy, heat, drying of coal, etc., as operating results show that in practice it is quite different from the conclusion that one forms at first: (1) Transport pipes are warm, not cold; (2) coal arrives at destination more dry than at start; (3) coal leaves the tank through 4-in. pipe at the rate of 2,000 lb. per min.; (4) coal falls into the tank through 8-in. diameter pipe at the rate of 500 lb. per minute; (5) the transport pipes never freeze.



Arrangement of blowing tank with air receivers and compressor

The following results were obtained from an installation at the Dilworth Porter Co., Pittsburgh, during the latter part of 1917. The results for a modern system should be far superior to those given herewith. The following shows the time required to fill the blowing tank through an 8-in. opening. When the valve opened, reading on scales or weight of coal in blowing tank was 500 lb. The drop during the first minute reading on scales showed 1,940 lb. in blowing tank; second minute, 2,300 lb.; third minute, 2,660 lb.; fourth minute, 3,040 lb.; fifth minute, 3,400 lb.; sixth minute, 3,800 lb.; seventh minute, 4,360 lb.; eighth minute, 4,850 lb.; ninth minute 5,280 lb.; tenth minute 6,440 lb.

It required 10 minutes to drop three tons of powdered coal into the blowing tank. This may be taken as the average time required, although it will vary according to the amount of moisture in the fuel, its temperature, the time it has rested in the overhead bin, and the size and shape of opening. The most astonishing feature of this transport system is the rapidity at which the fuel leaves the tank through the transport line, the air and coal passing at a rate of 2,000 lb. per min., causing the temperature of the conveying pipe to rise about 100 deg. F.

It is possible to increase the amount of fuel transported per minute by the increase of pressure which would always cause an increase in the temperature rise

of the pipe to the danger point of igniting the fuel being transported.

It is my opinion that 50 lb. pressure should be used for all distances and heights up to 1,400 ft., and although 35 lb. will be quite satisfactory for distances less than 800 ft., for extra long distances the pressure should be increased proportionately to overcome the friction in the transport line.

The rate at which the fuel will leave the tank may be seen from the following figure. The drop in air pressures should also be noted.

	Reading on Scales, Lb.	Pressure, Lb. per Sq. In.
Start	6,600	50
Blowing one minute	3,800	40
Blowing two minutes	2,060	40
Blowing three minutes	1,400	28
Blowing four minutes	1,200	15

The total fuel transported in 4 minutes a distance of 650 ft., making many turns, elevations, etc., was 6,600 — 1,200 = 5,400 lb., or an average of 1,350 lb. per min. These figures are reliable as they were taken during normal operation, no attempt being made for refinement in manner such as test results.

The illustration shows the apparatus used, consisting of a blowing tank and a 435-cu.ft. displacement air compressor, the delivery of which was tested by means of the known capacities of the air receivers.

The air receivers play an important part, as they must have sufficient capacity to provide enough air to blow the coal, otherwise it will die in the transport line, plugging the pipe solid.

The two receivers shown here were each 4 ft. in diameter and 18 ft. long and had a combined capacity of 452 cu.ft., and with an additional capacity of 20 cu.ft. in the aftercooler the total air-receiver capacity amounted to 472 cu.ft.

The air compressor working 7½ min., pumped air in the reservoirs to 95 lb. pressure at a temperature of 45 deg. F., which is equivalent to 6.4 atmospheres, or 3,020 cu.ft., approximately 400 cu.ft. of air per minute. If the compressor had pumped against a pressure 50 to 95 lb. per sq.in., it is probable that the delivery would not have been more than 360 cu.ft. actual air.

With these data it is a simple matter to find the total air required for transporting the 5,400 lb. of coal: 472 cu.ft. in receiver at 95 lb. pressure = 3,020 cu.ft. free air. Air compressor operated 3 minutes to fill blowing tank to 50 lb. pressure = 1,080 cu.ft. free air. Air compressor ran 4 minutes during the time of blowing = 1,440 cu.ft. free air. Total air pumped = 5,540 cu.ft. free air. Air left in receivers at end of blowing period at 50 lb. pressure = 1,585 cu.ft. Therefore the total air required to transport 5,400 lb. of coal = 3,955 cu.ft. This is equivalent to 1.37 lb. of coal transported per cubic foot of air.

From these figures it is an easy matter to make proper deductions for air receiver and compressor capacity, size of transport line, power requirements, etc. Roughly the power required may be taken at the following figures:

Receiver Pressure, Lb.	Tons of Coal per Hour	Horsepower Required
100	60	260
100	1	4.3
50	60	174
50	1	2.9
32	60	125
32	1	2.2

It should be remembered that these are old figures and that the present transport systems considerably reduce the power required.

Many of these systems have been in operation eight years, and so far as I have been able to learn, the maintenance has been practically nil. Of course we all know that there must be some wear and also some action due to the sulphur contained in the fuel.

The blowing tank should be heavily coated inside with some material as a protection against the sulphuric acid.

It is essential that periodical inspections be made, going over the entire system with a round-head hammer, to determine the thickness of the metal. Also, a hydraulic test should be applied to the blowing tank the same as if it were a boiler. As air receivers are necessary with this method of transport, the usual precaution should be taken for cooling the air and properly draining the water, oil, etc., from the receivers.

Renewing Elevator Cables

Inspection of elevator cables must be visual. Placing a stick of soft wood on the cables and allowing it to rub on them as they travel, in the expectation that broken wires will catch on the wood, is not good practice. In the first place, the broken edges do not always present a surface that will catch the wood. Again, if the edge does catch, it may pull the broken wire out of a strand in which no other wire is broken, and this end, when pulled out may cross the good wires and cause them to wear and cut.

As a general rule, hoisting and drum-counterweight cables should be replaced with new ones when six or more broken wires are found in any one strand. Car counterweight cables need not generally be replaced until about ten broken wires are found in a single strand. The necessity for changing hoisting cables depends somewhat on the load that they must carry. If the car has a capacity of, say, 1,500 lb. and is equipped with two ⅝-in. hoisting cables, it would not be advisable to recommend new cables until about eight wires are found broken in a single strand. If the inspector knows that the cables have been on the car for four or five years, however, it is fair to assume that some crystallization may be present, and then the cables should be replaced if there are six broken wires in a single strand. The testing of the cables under the average condition, when the cable has been in use for a year or more, cannot be satisfactorily accomplished by any means. If the cable is taken out and placed in a pulling machine, the condition under which it is tested will be so different from the operating condition that the results are of little account.

Not only is slow inlet velocity an advantage in reducing air friction and consequent pressure drop and power loss in an air compressor, but it also tends to stop the pulsations or pressure waves which often occur. Under suitable conditions these pulsations may actually serve to increase the volumetric efficiency and air output of a compressor by the inrush of air building up a pressure in the air cylinder at the end of the suction stroke and the beginning of the compression stroke. It is sometimes claimed that volumetric efficiencies of over 100 per cent have been obtained by this means, but this is only "apparent" by indicator diagram measurement. Actual air-quantity measurement by a nozzle will show that the other losses, such as clearance re-expansion, heating of intake and leakage, tend to keep the actual air quantity appreciably less than the cylinder displacement.

Sixteen Years of Boiler Standardization

By JOHN A. STEVENS

IF YOU ask ten business men on the street what interest they have in boilers and boiler construction, quite likely seven to nine of them would answer "Not any." But wait a minute! It is just possible that as they make this answer they are standing on a sidewalk where directly beneath them is a sub-basement that contains a boiler. Whether this boiler is to remain in its proper place or to suddenly leave that place, taking the sidewalk and them with it depends, among other things, upon proper construction, installation and handling. More likely the boiler is in the basement of an office building, and should it explode, the financier's desk may be in its path; even if it is not, he pays for the boiler and the building. Again, this man's own son may be completing training for important work to come, in one of our industrial plants where the improper placing or construction of the boilers would endanger his life along with those of other workers.

An early and consistent advocate of boiler standardization, Mr. Stevens, who retires as chairman of the A.S.M.E. Boiler Code Committee after thirteen years' continuous service, deserves much credit for what has been accomplished thus far.—Editor.

It was a group of incidents like these resulting, in one case, in the maiming and destroying of many lives; in another in the death of an owner's son, and both really due to faulty, though at that time usual, construction, which led in 1907, as many of the readers of this article will remember, to the establishing by the State of Massachusetts of a Board of Boiler Rules. This board was composed of men thoroughly conversant with the art of boiler construction, who set out to standardize the details of construction of steam boilers for use in the State of Massachusetts, employing the best commercial methods possible or, in other words, methods of construction that did not cost too much but at the same time were safe for steam boilers.

This board did its work so well that in 1911 the American Society of Mechanical Engineers appointed a small committee to review the work of the Massachusetts Board of Boiler Rules and expand and complete it. Because of the resources of the society and its prominence here and abroad, great interest was shown from the first in the promulgation of the A.S.M.E. Boiler Code, which today means a standardized steam boiler of the best known construction.

The small committee in the main adopted the Massachusetts rules for the construction of steam boilers, adding somewhat to these, but soon realized that they were working in too small a circle and expanded their organization by taking in an advisory committee which was soon made a part of the main committee. The Boiler Code Committee as thus established was formed of engineers representative of the railroad interests, boiler-insurance interests, consulting engineers, manufacturers of all types of boilers including marine and both steel and cast-iron low-pressure heating boilers, American Boiler Manufacturers Association, the technical press, National Association of Tractor and Thresher Manufacturers, National Association of Steam Boiler and Radiator Manufacturers, Engineering Department of the Interstate Commerce Commission and boiler users. In fact, there are represented on this committee all the large interests of the United States.

It is said that steam boilers used for the production of power alone amount in ordinary times to several million dollars' worth of business per year and that the heating boilers will amount to an equal figure, which will give one an idea of the volume of business done by the industry.

Since steam boilers were first constructed in the latter part of the Seventeenth Century, it has been known that boiler explosions are preventable, but the art of boiler construction and the demand for steam boilers grew so rapidly that, with the ever-increasing steam pressures, there has never been heretofore, with one or two exceptions in foreign countries, the establishing of specifications that would constitute a definite and true system of boiler construction and management such as is now available through the A.S.M.E. Boiler Code.

From the very first of this work, the Committee counselled with every known authority and consulted every standard possible to be secured, such as the best textbooks in print, British Lloyds, German Lloyds, Bureau Veritas, German Blue Book—State Pamphlet No. 2, which is a fine piece of work and which controlled all the boiler construction within the German empire before the war—the American Association of Steel Manufacturers, the American Society of Testing Materials, all the great insurance companies' standards and designs, as well as boiler companies' standards and the standards of consulting engineers who designed boilers individually for their clients prior to the standardization of this industry, and many others too numerous to mention.

Monthly meetings have been held since 1911 for consultation, conference and advice from the most skilled boiler engineers in the United States, as well as counselling with foreign engineers when members of the Boiler Code Committee were traveling abroad. In other words, the Boiler Code involves a résumé of all that is known of the art of boiler construction which it has been possible to procure up to the present time. This work has been so vast that, calculated on the ordinary rates charged for the services of the engineers involved in the production of this standard, the cost would have been at the least well over $1,500,000.

The object behind the undertaking was: First, to prevent boiler explosions and the destruction of life and property; second, not to increase the cost of boiler construction more than absolutely necessary; third,

to extend the life of all boiler installations even possibly to the extent of doubling the present life of the boilers; fourth, to standardize boiler construction which permits of production and tends toward America holding its higher, more comfortable living conditions for its citizens as compared with Europe and other parts of the world.

Illustrating that when you fire a proper shot, it may go round the world, this work has already permeated practically all of South America, Australia, New Zealand, eighteen states and fourteen cities of the United States, several departments of the United States government, and was used as a basis of the rules for the British Indian Empire. In addition all boilers exported to Turkey for several years have been built to the A.S.M.E. Code.

Reference to boiler explosions means major or disastrous explosions. There will always be derangements of boilers, such as the rupture of tubes or other minor parts, but boilers built in strict accordance with the Boiler Code should not explode, except possibly as the result of gross mismanagement.

Other Codes Found Necessary

In addition to the boiler construction code, we have other codes either published or in the process of preparation. A code has been published for the construction of those locomotive boilers not subject to federal inspection and control. There is a code for the inspection of steam boilers while being constructed in order that it may be positively known that the boilers conform to the Code in every detail. There is a code for the operation and care in service of steam boilers and other pressure vessels. A code has been prepared for cast-iron and steel steam-heating boilers limited to a working pressure of 15 lb. as well as a code for cast-iron and steel hot-water heating boilers for pressures exceeding 30 lb. per sq.in. There is a code for non-fired pressure vessels wherein all sorts of welded construction is used, and a code for steam piping. Other codes are under consideration for cast-iron and steel economizers. In other words, it has been found in this vast amount of research and the long years of practice of the people of the country constructing boilers to the A.S.M.E. Code that other codes are necessary for the maximum protection of human life and property by properly building all pressure containers or vessels carrying pressures of more than atmosphere, be it steam, air, gas, water or other substances. These codes are intended to have to do only with steam, gas, air or water and are not intended to cover mercury boilers or sulphur boilers. Also, the code has to do principally with boilers having a defined and confined water line and applies only in part to boilers of the so-called flash type.

When boilers are constructed and used to these codes, the specifications for their construction starts with the admixture of the ores in the blast furnaces and is supposed to continue to the end of the life of the boilers.

Prior to boilers being constructed to the Massachusetts and the A.S.M.E. Codes, they were often built without rules, being made up of a few plates, a few rivets and bolts, with a great deal of cast iron unwisely placed. The average life of such boilers has been pretty well established as being twenty or twenty-five years, but boilers constructed to the A.S.M.E. Code should last, in writer's judgment, when properly taken care of and with good boiler feed water or properly treated feed water, at least forty years.

I have removed water-tube boilers recently thirty-five years old, which were largely constructed of cast iron in their important parts, whereas every pressure part of a boiler constructed in accordance with the code for use in generating steam at the higher pressures now demanded, is of a tested and guaranteed steel and wrought iron. As an illustration of a case in point, tests are given herewith of steam boilers constructed in 1889 which operated with coal and hemp refuse for twenty-three years practically twenty-four hours a day. It will be noted that there was no deterioration in physical or chemical properties of the plate used.

Original Specifications by E. D. Leavitt, Cons. Engr. 1899		1914 Tests Boilers in Service October, 1892, to Jan. 1914, 21 yrs. 3 mos.	
No. 1 boiler.	No. 2 boiler....	No. 1 boiler coal burning.....	No. 2 boiler hemp burning
Elastic limit at least, 32,000 lb.		Elastic limit, 31,100 lb.....	24,200 lb.
Not in original specifications		Yield point, 39,000 lb.....	37,600 lb.
Tensile strength not over 60,000 lb.		57,500 lb.....	53,000 lb.
Elongation in 15 in. at least 25 per cent.....		Elongation in 8 in., 27.9 per cent	26.3 per cent
Not in original specifications		Reduction of area, 42.3 per cent	33.0 per cent
Carbon not over 0.001.....		0.0011	0.0011
Phosphorus, not over 0.0003		0.0003	0.00014
Not in original specifications		Manganese.....0.0052	0.0050
		Nitrogen.....0.000028	0.00029
		Silicon.....0 0001	0.0001
		Sulphur.....0 0004	0.00052

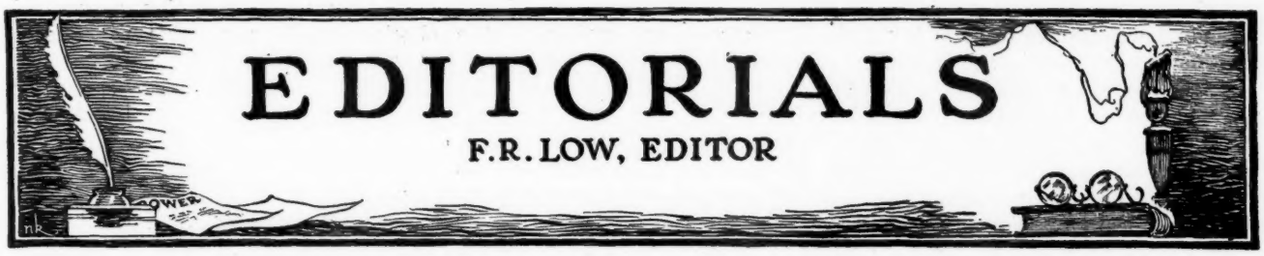
In addition to the foregoing data and statements, it is on record that there are boilers now operating in Philadelphia which are from 40 to 45 years old, and boilers abroad some 60 years old are still carrying moderately high pressure.

Bear in mind for the long life of boilers mentioned, I mean boilers built in absolute 100 per cent agreement with the requirements of the A.S.M.E. Code by skilled boiler constructors without haphazard, poor workmanship in any part of the structure. I also mean that from the day they are put into service they are to be handled by skilled operators and not by guesswork. Furthermore, boilers for this length of service should be scientifically inspected and to keep the boiler psychology correct, by a reliable insurance company who pays if anything goes wrong, especially when due to faulty inspection.

Increased Pressures Impose New Conditions

Owing to the ever increasing pressures which in all probability will be used in power plants of two to five hundred thousand kilowatts, it is obvious that a different class of men should be employed throughout the boiler industry from when carrying, as Watt carried, ten to twelve pounds, or eighty to one hundred pounds as was carried in the early 80's, for we now have boilers built and under consideration up to 3,200 lb. per sq.in., which puts stresses in the pressure parts of the boiler structure almost equivalent to ordnance stresses, and temperatures of superheated steam unthought of twenty-five years ago, approximately dull red in the dark.

The tendency to go higher and higher with pressures and temperatures may eventually make it desirable to employ grades of steel, possibly alloy steel, not thought of twenty-five years ago. These pressures and temperatures also give economies to the man who pays the bills, undreamed of ten years ago, and deliver power to the industries at the lowest cost—this, too, in the face of gradually diminishing and non-replaceable fuels such as coal and oil.



High Pressures Winning Converts

IT IS remarkable how the idea of the economy to be obtained by generating power from extremely high-pressure steam has suddenly seized the imagination of engineers after laying dormant in the textbooks for decades. George A. Orrok created something of a sensation at the annual December meeting of the A.S.M.E. in 1922, with his paper on the possibilities of high pressures and temperatures. In this connection it should be remembered that Mr. Orrok did not unqualifiedly indorse such pressures and temperatures, but stated that they gave strong indications of commercial advantage.

While this was not by any means the first time that the use of extremely high pressures had been suggested in this country, it was perhaps the first proposal of the kind where the combination of the occasion, the audience and the standing of the man making the proposal insured widespread interest and serious consideration.

Things were already moving under the surface at that time. Developments since then have been remarkably swift for such a radical departure. By the end of this year it is expected that at least two plants in the United States will be operating at 1,200 pounds steam pressure. These must be considered, for the present at least, as experimental plants. On the other hand, those who are building stations for pressures around 500 pounds do not consider their work experimental; that is, they do not feel that they are taking any unwarranted chances from the commercial point of view.

That high pressures are an important commercial factor even at the present moment may be judged from the fact that a single manufacturer now has built or on order 460,000 kilowatt hours of steam turbines designed for pressures of 550 pounds per square inch and up.

In all the hundreds of papers presented at the World Power Conference hardly a voice was raised against the use of higher pressures. Many spoke for them. To quote a few examples, V. Nordström, of the De Laval Company, Sweden, stated that steam pressures of from 750 to 1,500 pounds per square inch were within the range of practical possibility. Dr. Friedrich Münzinger, consulting engineer, Berlin, Germany, after a detailed discussion of the difficulties to be overcome, expressed confidence that the electric power stations of the future would operate at pressures ranging from 600 to 1,400 pounds and at steam temperatures from 750 to 800 degrees. In addition he said that such stations would use the regenerative cycle, steam accumulators in the low-pressure range to make possible the use of smaller drums in the high-pressure boilers, resuperheating of the steam, pulverized fuel and air heaters. Dr. Münzinger predicted a net saving on a total-cost basis of from ten to twenty per cent by increasing the steam pressure from 220 pounds to 1,400 pounds. In this respect he differs from some American engineers who have investigated the matter and reported no increase in the net commercial gain beyond 900 or 1,000 pounds. There appears to be a broad band of pressures within which there is little variation in the cost of a kilowatt-hour. It is conceivable that one station might use 500 pounds pressure, and another one in the same locality 1,000 pounds, and both produce power at practically the same unit cost.

To continue with opinions favorable to high pressures, Sir James Kemnal said: "The reason that I anticipate generating steam at pressures of from 500 to 1,500 pounds, superheated to 750 degrees F. or higher, is that experience with the lower pressure of 500 pounds is already sufficient to warrant incurring the extra capital cost involved in higher pressures, in view of the increased thermal efficiency to be expected." When considering this statement, allowance should be made for the higher ratio of fuel to construction costs in most foreign plants.

Whether these predictions are premature remains to be seen. While in this country we have had no practical experience whatever with pressures around 1,000 pounds, the prophecies look well on paper. The high-pressure horse may stumble and break his leg, but just now he looks like a winner.

A Governor on the Boiler Plant

EFFICIENCIES approaching eighty per cent have been obtained with hand-fired boilers installed in low settings. These results were not obtained at as high ratings as would be the case with modern stoker-fired boilers, but the figures show that it would be possible to reach about as high efficiency by hand firing as by any other method if the right kind of men could be obtained to do the firing. However, men that have intelligence enough to obtain these results generally do not stick long at shoveling coal, as there are plenty of opportunities for them to use their ability in other directions. As a result the average operating performance with hand-fired boilers is about twenty-five to thirty per cent below test results.

If the fuel and air are fed to the boiler at all times in the proper proportions and the boilers are kept clean, there are no reasons why operating efficiencies should not closely approach test results under the same conditions. But the trouble has been that in too many cases the feeding of the fuel and air has been made the function of a fireman, something that is practically impossible for any human being to do continuously. It is possible to put a man at the throttle of a steam turbine or an engine and have him control the speed on load changes to a degree, at least, where the machine will not run away and wreck itself. If the load is fluctuating widely one could hardly expect the human governor to

maintain good speed regulation. In this case all the attendant would have to do is to watch a tachometer or wattmeter and operate the throttle.

In the operation of boilers, which is a far more complicated process, the regulation has been left largely to the human element. When the complications entering into operating a boiler efficiently and the absence in many plants of proper combustion-control equipment are considered, the gap between test and average operating results is not surprising. A great deal of attention has been given to regulating the speed of the prime mover and the voltage of the generator. These have been made so nearly automatic that the function of the operator has become largely one of starting and stopping the equipment, watching any slight deviations from normal, making necessary adjustments and keeping and studying records. When the same thing is done in the boiler room, the wide difference between test and operating efficiency will largely disappear. In some plants this is being done and the operating figures show that a governor on the boiler plant is economically sound.

Protecting Steam Turbines Against Pipe Strains

AS UNITS grow larger, thrusts or twists due to steam piping become relatively more serious from the fact that clearances remain nearly the same, yet the lengths between bearings and the rotor diameters increase. Internal alignment is thus made a more delicate matter and larger pipes may exert increased stresses. Greater designed rigidity of the units, however, may tend to offset these conditions.

With the advance in steam pressures and temperatures more serious expansion must be dealt with and also stiffer and heavier pipe. Alignment is again at a disadvantage from the fact that since expansion is increased, greater allowances must be made in measuring and erecting pipe. Expansion from room temperature to that of saturated steam is about equal to the expansion from the temperature of saturation to that of 750 deg. F. steam at the usual pressures. Although greater flexibility is required, there is more difficulty in providing it on account of the heavier and stiffer pipe. Thus, while steam piping has given relatively little trouble in medium or small units, it has become a serious factor in those of large size.

The power-plant engineer is interested in protecting against pipe strains from two viewpoints. While in the first place it is desirable to limit pipe strains to the required amount, yet even more is it important to provide a condition whereby the correctness of his piping is established beyond all question. If a prime mover is installed in an acceptable manner as far as the steam piping is concerned, it may nevertheless develop a type of vibration whose characteristics are much like those of vibration produced by incorrect piping. In the latter instance the turbine builder is likely to question or perhaps condemn the header connection with the result that even elaborate tests may fail to establish the desired alignment condition and therefore result in the expense of a new design of header connection.

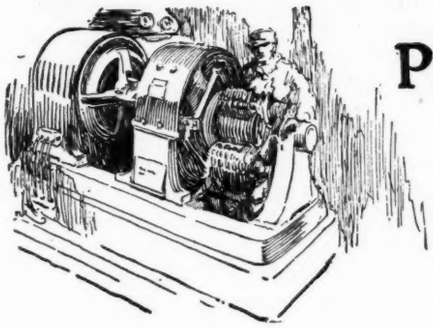
The effect of pipe strains on turbines can be measured in a number of ways. One method is to locate with trams the exact position of the turbine flange under normal running conditions to which the throttle valve or piping connects; then turn off the steam, disconnect the piping, and remeasure the flange location to see if this has changed its position appreciably owing to the elimination of pipe strain. Another method is to check the alignment between the emergency throttle valve if flexibly supported, and the turbine flange after carrying normal load with the steam turned off at the emergency valve. Measurements of this kind are often inconvenient and not always satisfactory as proof.

Exacting or tedious measurements, on the part of the power-plant engineer, may be avoided by supplying a rigid intermediate pipe connection between the header and the turbine, with the understanding that the builder is to supply satisfactory piping from this point to the unit. A firmly anchored elbow, strainer or separator may be utilized as such an intermediate connection. If the main header is connected with a reasonable degree of flexibility to such a stationary member, changes in the position of the former will not appreciably affect this fixed point. The turbine builder being responsible for the remainder of the piping, this leaves the purchaser free from complicated measurements, as acceptance may then be based on satisfactory performance only.

The principle of this method is not new by any means, as many turbines are manufactured with fixed throttle valves or steam chests, flexibly connected to the unit, the latter connection being furnished by the manufacturer. This plan has been somewhat further developed for turbines at extremes of pressure where an anchored steam chest is to be provided and the steam supplied thence to the unit by means of a number of smaller diameter pipes instead of one large pipe. There are instances, however, where the application of such a principle in the beginning would have been the means of saving subsequent expense.

In a recent report of the Federal Power Commission for the fiscal year ended June 30, 1924, it is stated that the proceeds from licenses totaled $53,713. Of this $24,109.42 was turned over to the general fund of the Treasury. An inquiring mind would ask, Why turn over to the general fund of the Treasury moneys collected by the Commission through its operation when the Commission is so hampered by lack of funds for personnel that it has to borrow from other services or make appeals each year to a busy Congress for an appropriation for money to carry through the year's work? This is just another case, like that of the Patent Office, where a department is made to appear as a liability to the Government, when in reality it is self-supporting or nearly self-supporting, through turning over its revenues to the general Treasury and then being obliged to beg for funds it has already furnished.

Although it is the middle of summer and warnings have been sent out repeatedly by the press and the departments of the government having to do with the question, coal is not being bought or stored this year to any extent by the coal-consuming public. The curve of production of bituminous coal, while not descending to the depths that were reached during the great strike of 1922, is consistently sticking, with slight fluctuations, at a lower point than has been reached during any other year of recent time. If some movement is not started very soon, next winter will find fuel again bringing high prices with uncertain deliveries and congestion in the transportation channels that will be so badly needed for food and grain handling.



Practical Ideas *from* Practical Men

Kinks One Engineer Has Used

The man who has charge of a power plant must always have one or more cards up his sleeve that can be played at crucial moments. These are his stock in trade and enable him to forestall accidents and prevent breakdowns and give him the power to apprehend future happenings.

A large cast-iron press beam, cracked in half, was being welded. It had been necessary to preheat it slowly in a forge for several hours before starting the welds, so that all warping would be prevented. The weld was two-thirds completed when the helper, coming from the storeroom, announced that there was no more welding rod. It took twenty-four hours to obtain more rods and the following day was a holiday. It seemed as if the work must stop and the casting be allowed to cool, thus losing several hours' time and taking the chance of spoiling the job. It was necessary to use the best substitute possible and avoid this. A quantity of heavy iron wire was snapped off a number of cotton bales that were on the receiving dock. They made an excellent substitute for welding; being very soft and flowing easily, they gave a good uniform weld.

Draw-filing of cast-iron cylinders, which often is a tedious job, producing uncertain results, can be accomplished by the use of knurling tools. The wheels, costing from fifteen cents up, can be obtained for all sorts of fancy finishes. Their use gives a uniform finish, shortening the time over draw-filing by one-half. It can well be substituted on cylinders for finishing presses and similar classes of textile machinery.

On brickwork in boilers a rich brown glaze for the side walls and arch is very desirable. When this is obtained, the surface is like glass and prevents clinkers becoming attached to the side walls. The addition of 12 per cent silicate (water glass) in the ordinary mixture of fireclay and ganister for the bonding of the brick, and a final wash of sodium silicate and fireclay for the surfaces will help to give this glaze.

In wet, damp or steamy places the rusting of measuring dials or polished metal surfaces can be easily prevented by first cleaning and polishing the surface thoroughly. Cover the dial with a coating of collodion which is transparent. When this has dried, give it a second coat. If the surface is not scratched or worn off, it will not rust, as the collodion prevents the air and moisture from coming in contact with the polished surface. Engine-room gages will last from six months to a year without repolishing if properly treated. Exposed copper and brass piping can also be successfully treated. Alcohol will remove the collodion for future treatments.

Leaky joints on steam lines can often be permanently stopped by the use of a calking tool and a little lead wool. Occasion frequently arises where a small leak in either a water or steam line is causing inconvenience and repairs cannot be made while the line is in service. A little lead wool worked tightly into the joint, the pressure on the line having been reduced while doing so, often obviates the necessity of making an expensive repair.

Sometimes a joint on a large flanged pipe line fails to meet and yet the flanges are too close to allow for a nipple. To make up this joint, take a piece of the next-size large pipe. Face the ends off in a lathe, making the length of the nipple or "Dutchman" the same as between the two flanges that will not meet. Cut two gaskets from $\frac{1}{16}$-in. sheet packing and force the lines apart so that the Dutchman, with a piece of packing on each end, can be squeezed into the opening. Pull the two flanges tightly together and evenly all the way around, long bolts being used. This makes a satisfactory job for medium steam and water line pressure.

Chicago, Ill. H. M. Toombs.

Repairing Holes in Commutators

For various reasons defects develop in the mica insulation between commutator bars. One of the chief causes of this trouble is oil getting on the commutator and destroying the insulating quality of the mica at some point. This starts a current leak, which gradually chars the mica until a path of low enough resistance is formed to cause serious heating. By this time the mica has been destroyed to a depth of $\frac{1}{8}$ in. or more.

One way to repair the defect is to open up the commutator and replace the defective insulation segment with a new one. This generally necessitates removing the armature from the machine and turning down the commutator after the repair has been made, both of which are objectionable if they can be avoided. As a result the defects are generally repaired by plugging the hole with some kind of filler. If a commutator is persistently developing defects in the insulation, it is a pretty good indication that the mica is defective and the best method of making a repair would be to reinsulate the commutator completely. If this is not done, a defect is liable to develop in the commutator that will burn out one or more coils in the winding, which will make necessary rewinding the armature.

When plugging holes in a commutator, care must be exercised to clean out all traces of burned mica before plugging the hole. If this is not done, any carbonized mica remaining in the defect will serve to form a leakage path through which current will flow between segments on the opposite side of the insulation. This leakage current will gradually destroy the insulation and cause another short-circuit between the segments.

There are a number of ways of repairing defective

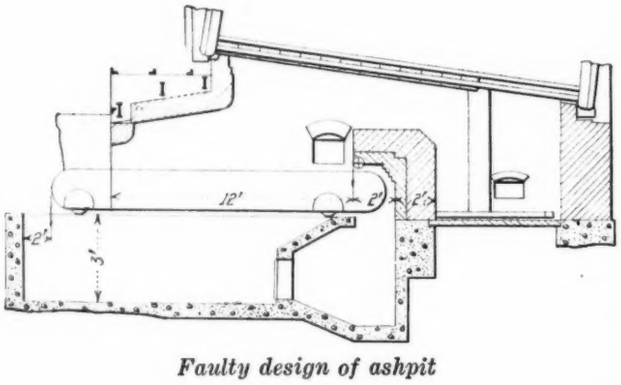
insulation in a commutator. If the hole, after being cleaned out down to solid mica, is ⅛ of an inch or more in depth, a piece of mica may be cut to fit, the hole coated with shellac and the mica driven into the cavity, after which it is smoothed down to form a true surface with the commutator.

There are pastes on the market that can be obtained for plugging these holes. Where these are not available, filling compounds may be made of plaster of paris and shellac, or in the absence of plaster of paris powdered chalk may be used. Another filler may be made from water glass and powdered glass. A compound that works out satisfactorily is made up of two parts of plaster of paris, one of powdered mica and sufficient glue or shellac to make a thick paste. This filler will dry quickly and become quite hard. B. A. BRIGGS.

Boston, Mass.

Poor Ashpit Design

The illustration shows a design of ashpit frequently used but altogether undesirable from the viewpoints of labor involved in removing the ashes and inconvenience and danger to the operator. It will be noticed from the drawing that ashes drop off the rear of the chain grate into an inclosed compartment, the only access to this compartment being through a 14x14-in.



Faulty design of ashpit

door. There is only one door of this size, and the ashpit is 10 ft. wide. In this particular installation the distance from the front of the ashpit to the stoker chain is slightly less than two feet, and the depth of the ashpit three feet.

When removing the ashes, the fireman is forced to protect his head and shoulders with, let us say, a piece of carpet, squeeze down between the front part of the ashpit and the chain and walk back in a stooped position toward the rear of the pit. As the three-foot headroom does not allow him to stand upright, it is necessary for him to perform his work in a cramped position, and if it were not for the carpet over his head and shoulders, the hot cinders dropping from the stoker would make him most uncomfortable.

Working in this cramped position, he opens the door to the closed compartment at the rear and hoes the ashes from the central portion through the door. He then shovels these ashes forward away from the door, so that he can crawl through into the compartment and shovel out the ashes from the corners. After the closed compartment is emptied, he crawls out over the hot ashes, closing the door behind him and trying as best he can to keep the carpet covering over his head.

Still working in a cramped position, he shovels the ashes to the front part of the pit and then out through the narrow opening between the end of the pit and the front port of the chain. In this narrow space it is awkward work to remove the ashes, and particularly so as there is considerable droppage from the stoker at this point. From the boiler-room floor the ashes are shoveled into a barrow and wheeled away.

I do not know of any design of ashpit where the labor cost of handling is any greater than in this instance, nor of any more awkward, disagreeable and uninviting job than that of the man who has to go into such a pit. In case of a tube failure the ashman's life is in danger in the closed compartment, and there is little likelihood of his being able to escape through the narrow opening at the front of the ashpit.

If the person responsible for this ashpit design could be made to handle the ashes himself, he would then understand the awkwardness, the danger and the high labor expense involved, and it is certain he would give more attention to the comfort, convenience and the safety of the boiler-room operator in future designs.

Chicago, Ill. R. C. WARNER.

Value of Instruments in the Boiler Room from the Fireman's Point of View

We have been told repeatedly that recording instruments on drafts, steam flow, air flow, flue gas, feedwater temperatures, steam pressure, etc., will save money and pay handsome dividends. The savings, however, have invariably been attributed to the working out of, or the setting of a certain standard or goal and the firemen being required to meet this standard.

Many engineers think that all they have to do is to get modern instruments and pay the current wages and results will be immediately forthcoming, and in many cases the results are all that could be expected. In other cases conditions are different and the average results are perhaps not as good as they had been when we take into consideration the equipment and appliances that we have today as compared with those of 10 or 15 years ago.

Some executives do their best to discourage or break down the pride in men. It seems that most modern industrial plants have only one idea in mind, and that is to compel men to do certain things against their wishes. If they can compel compliance with a lot of rules, they feel satisfied, regardless of the efficiency in certain departments, the power plant included.

So we find by experience that if instruments are introduced in the proper way and if a little bonus of some sort is offered and the men are taught to take an interest in the lines recorded on the chart and are taught the right, best and easiest way to produce the desired lines, they will in most cases automatically take pride in the results obtained and put forth their best efforts in improving the operation of the plant.

We can go still farther to secure their interest and enthusiasm by asking them to offer suggestions, especially in meetings where there are firemen present. The written idea is seldom successful—that is, what we call the suggestion box—because the man can seldom explain the idea properly on paper; whereas if it is taken up in a meeting and discussed, the real merits of the suggestion will be brought out.

Tonawanda, N. Y. WALDO WEAVER.

Comments from Readers

"Reburning" Flue Gases

In the June 24 issue W. S. Findlay describes a scheme for "reburning" flue gases. In short, he would take the gases of combustion from one boiler furnace and pass them through the combustion chamber of another to utilize the 6 to 10 per cent of oxygen therein contained, as well as the sensible heat of the gases. This scheme seems to be a reaction from the suggestions to use pure oxygen, which is not at present feasible because of the high cost of the oxygen.

I presume that everybody that has analyzed gases from boilers with defective baffling has thought of their possible use again in support of combustion because of the large oxygen and heat content. But to use gases containing 6 to 10 per cent oxygen (and 13 to 9 per cent carbon-dioxide) would not seem practical, particularly when there is trouble enough in ordinary practice to get complete combustion with air containing 21 per cent of oxygen.

About fifteen years ago I made some tests to satisfy about "extinguishing atmospheres." We thoroughly saturated a dry pine board with kerosene, ignited it and, when it was burning briskly, tossed it into the third pass of a boiler. A wire had been attached to the board to enable us to recover it as well as to keep it suspended in the gas stream, a notch being made in the cast-iron door to accommodate the wire. After fifteen minutes had passed, during which time we sampled the gases and got the temperature in the third pass, we withdrew the board. Instead of being entirely consumed, it bore evidence of having been extinguished immediately on entering the gas stream. On being exposed to the air, a few places at the edges of the board glowed but did not flare up. The gas sample gave 10.7 per cent CO_2 and 8 per cent O_2 and no CO. The temperature as taken with a "stack" thermometer was 790 deg. F.

We repeated the experiment with the furnace-inspection door and the stoker coal gate open in order to admit a large volume of air. The gases sampled gave 3.6 per cent CO_2, 15.3 per cent O_2 and no CO. The temperature at the third pass was 602 deg. F. This time the board was partly burned, which indicated that if sufficient time had been given, it would have been consumed.

Tests in connection with coal-mine ventilation problems have demonstrated that atmospheres containing less than about 16 per cent of oxygen are extinguishing to flames from alcohol, petroleum oils and various gases. In these tests the atmospheres were at room temperature and, of course, did not indicate what may be expected from higher temperatures.

In future tests Mr. Findlay might analyze the gases leaving the setting, for the purpose of learning whether the gain from using a comparatively high-temperature flue gas is not offset by a loss from incomplete combustion. It seems to me that progress in combustion practice will more likely be made by the use of economizers and air preheaters than the use of atmospheres containing a deficiency of oxygen. Also, that the amount of improvement from the use of "second-hand" air, obtained by manipulation and additional apparatus, might be had more cheaply by equal care in the use of "new" air.

C. O. SANDSTROM.

Kansas City, Mo.

Speed Regulation of Underfeed Stokers

I am rather inclined to agree with Mr. Richardson's remarks in the July 1 issue on the "Speed Regulation of Underfeed Stokers." A number of years ago, when the underfeed stoker was just coming into use, one of the great talking points was that the stoker mechanism and fan were both driven from the same engine so that the fuel and air supply were always in the same proportion. This looked fine, but unfortunately in practice so many emergencies arose in which is was necessary to have independent control of stoker speed that the use of separate engine or motor drives became almost universal.

This does not detract from the theoretical advantages of accurately proportioning fuel and air supply. It is well recognized also, that if coal feed is continued at a high rate with low windbox pressure, a tough dense coke will be formed with most Eastern coals that will give poor results until it is worked through the fire. Aside from this on the one hand, and having the stoker practically stopped with full windbox pressure, what guide has the fireman as to what is the correct stoker speed he is to run at for any windbox pressure? Even with a reasonably uniform coal supply there is enough difference between wet and dry, lumpy and fine coal packing in the hoppers and partly filling the ram cylinders so that the fireman is thrown back on observation of the thickness of the fire. Where there are CO_2 recorders and other combustion control instruments, he may judge if he is maintaining his fire in condition to produce the best results.

When it is considered that there is often coal enough for two or three hours' steaming on the grate, it takes some time for a change in adjustment to become visible, so that while with stoker tachometers, the fireman can in a general way follow the average load and avoid thickening of his fire to an unwieldy point, then when it lightens up it is of minor importance for him to attempt to follow all the small fluctuations of windbox pressure either by hand or automatic control.

Another reason for this is that both the Bureau of Mines experiments (Tech. Paper 137) on carefully controlled fuel beds and gas analyses under working boiler conditions show that within reasonable limits, the rate of combustion is determined by the rate of air supply, and that with a reasonably uniform fire practically the same composition of flue gases will be obtained at high as at low rates of air supply. Therefore, aside from flue temperature there will be no great change in chimney losses, so that, if a fuel bed is maintained to

correspond with the average load, no material losses can occur with variations in windbox pressure and the fireman will be relieved of unnecessary effort or the care of one more piece of machinery to go wrong at a critical time.

From curves shown it is impossible to tell just what the air-flow figures represent or how they were measured. From the fact that they do not correspond to the CO_2, which is also a measure of air supply, one or the other must be in error. I assume from the nature of the scale and the form of the curve that they were read from a steam-flow-airflow meter and were obtained by altering the position of the flue damper, in which case there will be sufficient air leakage through brickwork, door openings, dump grates and ash hoppers to bring the airflow reading up to correspond to the damper opening, without its showing upon the CO_2 which is usually taken near the center of the boiler passes as this air leakage usually follows the sides of the setting through the boiler. In a way such readings are somewhat misleading for, while they show there is a condition that requires correction, it is not in the fire, which it is supposed to represent the condition of, but elsewhere. One thing that can apparently be deduced from the curves is that for boiler No. 5 on Feb. 19, 1924, the rate of coal feed was a little greater than the load, and the fire, which at first was too thin, gradually built up until it was about right. Boiler No. 1 on Feb. 18 operated under good conditions without definite variation enough to draw any conclusions, and for the whole run of boiler No. 1 on Feb. 21 the average rate of coal feed was so well maintained that the fire was practically unchanged over the whole period.

While I believe it would have made a more convincing argument if Mr. Richardson had plotted his windbox pressures and steamflow readings along with his other data in the curves of Fig. 1 and Fig. 2, I agree thoroughly, both from theoretical and practical grounds, with his conclusion that automatic stoker-speed control will do little to increase the efficiency of the boiler or decrease the attention to the furnace required of the fireman.

H. D. FISHER.

New Haven, Conn.

Lime Saving by Hot Treatment of Hard Water

The excellent and profitable results obtained from a hot-process water softener as reported by James E. Durfee on page 11 of the July 1 issue parallels my own experience. The savings effected by such an installation—or indeed any installation that really results in proper boiler-water condition—are a source of surprise to those who have not carefully investigated the subject. But I am particularly interested in Mr. Durfee's remarks on the softening action obtained by heat alone.

To quote from the article in question, "In addition to the action of lime and soda ash in removing incrusting solids, heat removes a large part of the calcium-carbonate hardness. There is a daily saving of about $3.25 in lime due to the removal of the calcium-carbonate hardness by the action of heat." Now in the table given in the article in question the author reports 162 lb. of lime costing $1.62 and 169 lb. of soda ash as being used per day. Then the cost of the lime, if none of the calcium carbonate was removed by heat, would be $1.62 plus 3.25, or $4.87 per day. In other words the author thinks that approximately two-thirds of the temporary hardness is removed by heat action.

$$\left(\text{Ratio } \frac{\$3.25}{\$3.25 + \$1.62} = \frac{2}{3}\right)$$

Now this may possibly represent the saving in lime effected by a hot-process system as compared to the cold-process system he previously used, but I am loath to believe it is due to reduction in hardness brought about by heat action. The water in an open heater is subjected to boiling action for less than one-half minute. The rest of the time it is in the heater or storage tank in a quiescent state; that is, it is not boiling.

A Miami Valley well water with which I am familiar has, roughly, the following analysis: Calcium carbonate, 13 gr. per gal.; magnesium carbonate, 7 gr. per gal.; calcium sulphate, 5 gr. per gal. This water obviously has a "temporary" hardness of about 20 grains and a total hardness of 25 grains per gallon. A sample of this water, which in the raw state actually titrated 21 grains alkalinity per gallon using methyl orange as an indicator and 24 grains per gallon hardness on the soap test, required thirty minutes' violent boiling to obtain an alkalinity of 6 grains and a hardness of 11 grains. The reduction in hardness was 13 grains if we go by the soap test or 14 grains if we go by the methyl orange, and represents about 70 per cent $\left(\frac{14}{20} \times 100\right)$ of the temporary hardness. In one minute less than one-fourth of this reduction was obtained; just how much less I cannot state precisely, but I feel safe in saying the great reduction in lime usage in Mr. Durfee's case is the result of eliminating excess lime rather than in reducing the temporary hardness by heat.

Mr. Durfee's statistics would also seem to bear out this view. The ratios of the lime to soda ash in the theoretical lime and soda-ash treatment of the Buda and the Harvey City waters are 73 per cent and 90 per cent, respectively. But the ratio of the lime to soda ash which he gives in his table (162 lb. lime to 169 lb. soda ash) is 96 per cent. In other words, if we accept Mr. Durfee's statement that he has no excess soda ash, then he must be actually using a lime charge in excess of the theoretical charge regardless of which one of the two waters he may be using. However, observation of a hot-process softener over a considerable period of time leads me to believe that the actual charge does not vary much from the theoretical, but will generally be found to be *somewhat* less.

In this connection the advantages of partly or wholly deaërated makeup water may be noted. Where water that has passed through a low-level jet or barometric condenser can be used rather than raw water, there is generally an appreciable saving in lime aside from any heat saving. Probably all natural waters contain free carbon dioxide and many waters—particularly those coming from wells—contain considerable quantities of it. In a case that came under my observation, the lime requirements were reduced between 10 and 20 per cent by deaërating. Deaërated water also has in such cases a marked effect in reducing the amount of steam lost through the air vent in atmospheric heaters.

It would be highly beneficial if some of our specialists on water treatment would obtain and publish authoritative data on deaëration and heating in their relation to the chemical treatment of feed waters.

Dayton, Ohio. GUY B. RANDALL.

The Steam-Heating Business

I have read with interest the editorial in the July 1 issue entitled "Profit in Central Steam Heating."

Apparently the report of the Committee on Operating Statistics of the National District Heating Association at the recent New York Convention indicates about a "fifty-fifty" split on the question of whether central steam heating is profitable. I am not surprised at such a report, because few of the "so-called" successful central-station operators are sold on the heating business, and this business has been generally condemned by the electric-utility operator. Not, however, because there is any sound reason for its failure to produce satisfactory returns, but rather because the business has been more difficult to develop than has the electric situation, and the heating has therefore been poorly managed.

The heating business was first introduced largely in situations where two companies were in severe competition for the light and power loads. The well-known fact that about 90 per cent of the heat entering the throttle valves of steam prime movers reappears in the exhaust steam at atmospheric pressure, caused the promoters of our first heating systems to sell, or rather, give away the steam heating at ridiculously low prices. They proceeded on the theory that since exhaust steam was a byproduct of the power operation, it could be sold at any price and still yield a handsome profit. They used the heating service merely as a means to get the electric load and paid little or no attention as to whether the heat was yielding a profit.

On the other hand, during the franchise negotiations of some of the earlier heating companies many foolish steam mains were laid to serve certain political connections, regardless of the economic returns from such expenditures or their effect on the general distribution system as a whole. Many of the earlier systems have been, and some still are, afflicted with these loose and unprofitable ends.

There is another angle to the central-station business, with respect to the condemnation of heating. The central-station industry is largely dominated by the electrical engineering fraternity, and it is further dominated by the commercial development viewpoint rather than by the economic one. As a result the heating situation has been looked upon as a minor problem to overcome, whereas in reality it is the major one in permanently holding the electric load.

The problem now confronting many of the large central stations of the country is one of devising methods to hold the electric business permanently in the densely built-up sections of our urban centers and also in many of the industrial plants. The only means so far devised to combat the isolated plant successfully is by furnishing the heat as well as the electric light and power services. The purchasing public has a much keener appreciation of good heating service than it has of electric service. Heat, once sold and satisfactorily delivered, is sold forever.

In the territory north of, say, 35 deg. North Latitude, we can in this country, where most of our large cities are situated, figure on a heating season of from six to eight months. The buildings in this zone will require heat of some kind. If this heating service cannot be supplied from an outside source, boiler plants must be installed in the buildings where the kilowatt-hours go. The size of these boiler plants is not, in most cases, influenced in the slightest degree by the fact that electricity is not produced from them, and during the major part of the year the coal they burn is not reduced an appreciable amount either, by the absence of the electric light and power loads.

So, from an economic standpoint the mere act of supplying electricity has not, by any means, permanently solved the problem, particularly with the increasing price of coal. The higher the price of coal the more difficult it will become for the central stations to hold the electric business in large buildings and industrial establishments, which necessarily have to operate boiler plants for heating.

The central stations have tried to win by foisting onto the building owners low-pressure boilers, which were unsuited for power-production purposes, and in this way forced them permanently to provide electric loads. However, in the large buildings these low-pressure boilers, to which most architects for some unexplainable reason are wedded, cannot be used on account of their necessarily small size. Thus for the larger business in the thickly built-up sections of our cities, the companies having heating systems will produce far better results in permanently holding their electric business than the operators will who "kid" themselves that the heating business is no good.

Central Heating Means Few Isolated Plants

The best indication that I know of to show whether the heating business is profitable or not, is disclosed by the fact that in the cities having substantially built and well-operated heating systems, we find the fewest isolated plants.

Milwaukee has one of the most substantially built and probably also the most densely loaded heating systems in this country. This now heats substantially every business building in the congested downtown section, which comprises about one and a quarter million cubic feet of space. There is not a generating plant in the entire district it serves except one hotel, and this has an isolated plant that sells heat and light to the entire block in which it is located.

By the way of contrast as to the possibilities, the Milwaukee system has less than five miles of mains and it produces in revenues about three-quarters of a million dollars per year. In the Loop District of Chicago, there is constructed under the streets 62 miles of tunnels in which is operated a toy freight transportation system, connected to practically all the buildings. This 62 miles of underground railway in that area produces less than twice the revenues that 10 per cent of heating-main mileage produces in the City of Milwaukee, 90 miles away.

Junk the toy railroad in the Chicago tunnels and build therein a well-designed heating system and feed it with exhaust steam, and every boiler plant and isolated generating plant can be permanently shut down at a handsome profit for the company having the nerve to carry it out.

Abandon the heating systems in the cities now having them, and the builders of isolated generating plant equipment would shout with joy. When the central-station operators begin to realize there is something to look at besides the kilowatt-hour and then begin to worry about the B.t.u., the heating business will look different to them.

Egbert Douglas.

Milwaukee, Wis.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Indirect Radiation

What is the method of operation of a stack heating system for a schoolhouse or other building? H. M. S.

Heating engineers sometimes apply the term "stack" to any assemblage of radiator sections or other form of steam or water heated surfaces when used as indirect radiators, that is, radiators that are located outside of the room to be heated, and the heat is conveyed from the radiator to the room by a current of air passed over the radiator surfaces. To avoid confusion, it is better to refer to radiators used in this manner as "indirect radiation" rather than stacks, since the latter term is so commonly used with reference to the smoke chimney.

Distribution of Exhaust for Warming Buildings

Where heating of several buildings that are near together is done by exhaust steam from one engine, what is the best method for running the steam and return mains? L. H.

The best drainage for steam mains and branches can be obtained when the main steam riser extends to the highest points of the buildings with steam mains and branches reduced downward. Then the gathering together and elevation of the return mains are independent of the pitch required for proper drainage of the steam mains, running of the return lines is simplified and valuable space of basements or lower stories is not taken up or overheated by the presence of large steam mains or special provisions for their drainage.

Obtaining Engine Friction Diagrams

In indicating an engine to obtain friction diagrams for power measurements, is it essential to have the same speed and initial steam pressure as when the engine is loaded? W. C. M.

Strictly speaking, friction diagrams should be taken with the initial steam pressure and regular running speed obtained by adjustment of the governor, if necessary; but for all practical purposes the diagrams may be taken with the regular speed approximated by throttling. In any event, the r.p.m. allowed in computation of the friction diagrams should be the same as that of the engine when it is loaded. The main advantage of throttling is to obtain diagrams that can be accurately measured, by their showing the expansion lines distinct from the exhaust and the atmospheric line. The average of a number of diagrams should be taken with the engine running at a uniform speed so that duplicate diagrams may be obtained, and for greater accuracy in measuring a friction diagram, where it would be uncertain from confusion with an atmospheric line, the latter may be better omitted.

Double Stop Valves on Boiler Connections

Why is it necessary to provide two main stop valves for a boiler? R. L. H.

Where a plant is equipped with a single boiler, it is not essential to provide two stop valves in the steam line, except as a precaution against one of them getting out of order. Then there should be a good-sized drain connection between the stop valves, to relieve any leakage of steam by the valve that is nearer to the boiler, which might find its way through the other valve, in case it is desired to prevent delivery of any steam to the line. But when two or more boilers are connected to a common steam main, there always should be two stop valves on each boiler, with an ample free blow drain between them, placed in the steam connection between each boiler and the steam main, to prevent steam from backing into the boiler when it may be desirable to preclude steam from the line in case of accident, or during cleaning, inspections, alteration of connections or repairs. The discharge of the drain valve between the stop valves should be visible to the operator while operating this valve. When an automatic non-return valve is used, it should be set next to the boiler with the blow drain between the non-return valve and the auxiliary stop valve.

Obtaining Compression in Single-Eccentric Corliss Engine

On a single-eccentric Corliss engine why is not compression obtained by simply lengthening the exhaust-valve rods for the purpose of obtaining closure of the exhaust valves before the end of the stroke? W. N. S.

Such adjustment of the exhaust valves would make them later in opening as well as earlier in closing, and steam would not be released until after the piston started on the return stroke, whereas, to obviate excessive back pressure in the beginning of the return stroke, it is desirable to have release occur before the end of the admission stroke. Hence, to obtain compression without choking the exhaust, it is necessary to adjust the exhaust-valve rods to such lengths that the exhaust valves have little or no lap when the wristplate is in central position, and obtain earlier release and compression by setting the eccentric ahead of the 90-deg. position.

From advancing the eccentric for accommodation of the exhaust valves, all valve events occur earlier, and since the wristplate is thus brought up to the central position before the beginning of the stroke, to prevent excessive lead it becomes necessary to adjust the steam-valve rods so the steam valves will have lap when the wristplate is in the central position.

Cleaning Water Gage Glass Without Removing It From Fixtures

How can the water gage glass of a boiler be cleaned without removing the glass from the fixtures? *S. R. D.*

At a time when there is 5 to 10 lb. pressure on the boiler, draw about a pint of hot water from a gage cock into a shallow cup and add a tablespoonful of muriatic acid. Close both water-gage valves, open the pet cock at the bottom, and blow the water out of the glass. Then immediately close the top valve and submerge the end of the pet cock in the cup of hot acidulated water. The partial vacuum formed in the gage glass will cause the solution to fill the glass. Keep the pet cock immersed and operate the top valve by slightly opening and closing, alternately expelling and drawing in the solution until grease or other dirt is cut out of the glass.

Movement of Engine Frame Not Preventable by Compression

Where an engine rocks or there is vibration of the foundation, cannot such movements be prevented by compression, or cushioning on the steam in the cylinder? *W. L. C.*

Rocking of the engine frame, movement on the foundation or movement of the foundation with the engine result from lack of balance of rotating parts or from the inertia of reciprocating parts transmitted to the engine frame. The effect of compression or cushioning on the steam in the cylinder, during retardation of the reciprocating parts, is to remove the retarding force from the crankpin and transfer it to the cylinder, where it is transmitted to the cylinder and frame through the cylinder head, instead of being transmitted to the frame through the crankpin. Hence, the net result on the engine frame and foundation is the same with or without compression.

Sizes of Pump Suction and Discharge Lines

Why are pump suction lines made larger than the discharge lines, and what determines the size of each? *W. L. F.*

The pipe sizes are determined by the loss of pressure from pipe friction that is permissible when the pump is operated at fullest required capacity. For a given length of pipe the pressure required to overcome pipe friction is nearly inversely as the diameter and directly as the square of the velocity or quantity of water flowing per minute. Under ordinary conditions suction pressure is constant and is sufficient to supply the pump and overcome the pipe friction and friction of the pump passage when the suction pipe diameter is of such size as to require no greater suction water velocity than 240 ft. per min. That is, when

$$\text{Diameter of suction pipe in in.} = \sqrt{0.1 \text{ gal. per min.}}$$

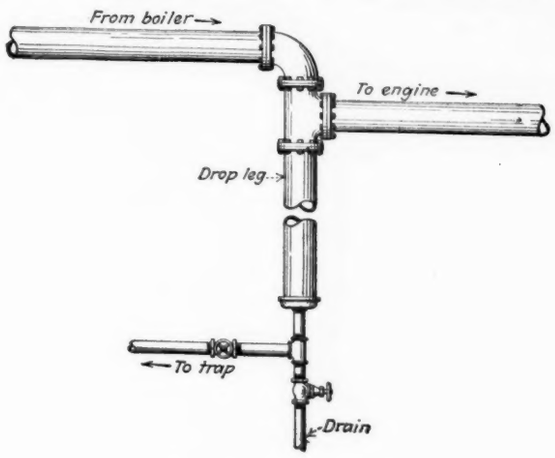
The loss of pressure permissible in a discharge line is limited only by the strength of the pump and the power available for its operation, and as the loss of pressure in the discharge line for a given rate of pumpage is a matter of choice, the size of discharge pipe may be much less than necessary for the suction line. But under average conditions it is advisable to make the discharge pipe of such size that the velocity is not in excess of 300 ft. per min.; that is to have

$$\text{Diameter of discharge pipe in in.} = \sqrt{0.08 \text{ gal. per min.}}$$

Drop Leg for Receiving Water in Excess of Separator Capacity

We have a single-valve high-speed engine that is supplied with steam through a pipe line that is about 250 ft. long. There is a standard size separator in the steam line, but we often have trouble from water getting in the cylinder, once causing a smash when the engine was started. How can this trouble be prevented? *D. L.*

It must be that water is sometimes carried over from the boiler and there are traps in the line from which sufficient water is swept along with the steam to flood the separator. The line should have a uniform pitch toward the engine without traps and be covered with a good non-conducting material. As the capacity of



Drop leg in steam line

the separator and its drain are limited, there should be a drop leg in the main line for gathering extraordinary water. The drop leg should be near the engine and, as illustrated, it should be provided with a drain and steam trap.

Safety Valve for Closed Heater

When feed water is pumped through a closed heater that is suitable for higher pressure than the bailers, is it necessary to provide the heater shell with a safety valve? *B. N.*

The shell of a closed heater always should be provided with a safety valve. When the boiler feed pump is in operation and air feed line valves are open, on account of the pressure required for overcoming pipe friction the heater shell may be subjected to considerably higher pressure than the pressure in the boiler. Should the boiler-feed stop valve be closed and the pump steam and discharge stop valves open only the least amount, without a safety valve on the heater, the pressure would be limited only by the maximum dicharge pressure that can be exerted by the feed pump, which in most cases is more than twice the boiler pressure. Neglect of safety valves on closed heaters, set to relieve the pressure in excess of the safe working pressure, have been the cause of some serious scalding accidents.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Ten More Fallacies

AN ARTICLE in a previous issue exposed ten common fallacies in the field of power-plant engineering. Some of these were current even among engineers and others only among the non-technical public. The present article deals with ten more fallacies of the same sort.

11. Hydro-electric power will eventually displace all steam-driven power plants.

For proper consideration this proposition should be divided into two parts: *In the future no power will be generated by steam* and *hydro-electric plants will furnish all the power in the future.* The first is highly improbable and the second inconceivable. It would of course be rash to make the positive statement that steam plants will never pass into the discard, because they could all conceivably be replaced by gas or oil engines or even by plants operating entirely with the vapor of mercury or some other substance than water. The use of these other forms of power will doubtless increase, but the complete passing away of the steam plant seems only a remote possibility. However, this point is debatable, so that this half of the proposition standing by itself is not a demonstrated fallacy.

With the other half it is different. If all the power of the future is to be generated by water, we must be content with no more power than the total we are now using. Reliable estimates indicate that if all the available water power of the United States were developed, it would just about meet our present requirements. Efficiencies are already so high that increasing them to the full theoretical 100 per cent would not greatly increase the available power. With the power consumption of the country doubling every few years it is hard to imagine the much greater population of the future being content to get along on a mere pittance of power as long as fuel was available. The known coal supplies will not be exhausted for hundreds of years.

12. Plants that are making smoke ought to put smoke consumers in their stacks to stop the nuisance.

Engineers know better, but the general public still thinks that a power-plant owner can go out in the market and buy some sort of a device that will eat up smoke like a horse eats oats. The public has a right to complain of the smoke nuisance and is right in considering it preventable. New plants, if properly designed, should be practically smokeless. Old plants can be made so if enough money is spent in reconstructing the settings, etc. Right or wrong, many owners feel that they cannot afford the expense. The least they can do in such cases is to employ an operating force with sufficient intelligence to keep the nuisance at a minimum.

13. In times of fuel shortage it is in the public interest for consumers, so far as possible, to use electricity for warming their homes.

This advice was actually given during a recent coal shortage. Neglecting the fact that it would cost several thousand dollars a year to heat a small bungalow in this fashion, such action, obviously, would waste fuel rather than save it. The average central station consumes at least 2 lb. of coal for each kilowatt-hour delivered to the customer's house. Allowing for the high efficiency of electric heating devices, it would take 2 or 3 kilowatt-hours to furnish as much heat as one pound of coal burned in the householder's furnace. Thus each pound of coal "saved" in this way would waste about five pounds at the other end of the line!

14. The carburetor will extract every ounce of energy from the gasoline.

This claim, once made for the performance of an automobile carburetor, is typical of the loose use of technical terms which is still common in popular literature. In the first case there is no such thing as an ounce of energy or pound of energy for that matter. Then no carburetor extracts energy from the gasoline. It merely vaporizes it so the engine will have a better chance to extract the energy. Finally, neither the carburetor nor the engine nor any other piece of power-producing apparatus can extract all the energy from the fuel—far from it, in fact.

15. Among the savings obtainable by replacing an isolated plant by purchased power are the interest and depreciation on the displaced equipment.

Ceasing to use an article does not eliminate the interest cost on the money invested, nor, in most cases, does it have any marked effect on the rate of depreciation. If the machinery has reached a condition where it must be replaced to continue longer in operation, then interest and depreciation on the cost of replacement are saved by closing down the plant and purchasing power.

16. While bare-pipe losses are serious in winter, it doesn't matter much whether a steam line is covered in the summer.

This statement was actually made to an insulation salesman by the engineer of a small oil refinery. It was a hot summer day and the bare 4-in. pipe in question ran through a room where the temperature (with the help of the pipe) was around 90 deg. The fact of the matter is that the pipe was losing about three-quarters as much heat as if the surrounding air had been at a temperature corresponding to freezing.

17. Efficiency doesn't matter much where most of the fuel is manufacturing waste.

Suppose 80 per cent of the power is generated with waste fuel and the other 20 per cent with purchased coal. Assume that, with the amount of power produced remaining constant, the efficiency is improved so that one kilowatt-hour can be produced with 20 per cent less fuel (either refuse or coal). The refuse that formerly generated 80 per cent of the power will now generate all of it. From studies of this sort, the conclusion may be drawn that, where waste fuels are "pieced out" with coal, increased efficiency saves as much coal as if no other fuel were used. This, of course, applies only up to the point where no coal at all is needed.

18. Central stations are always more efficient than small isolated plants.

There are many exceptions to this. Compared on the basis of B.t.u. per kilowatt-hour, the small Diesel-driven plant is more efficient than the largest steam-driven central station. When all the exhaust steam is needed for process or heating, a small isolated plant with simple engines can generate power for a coal consumption of ½ lb. per kilowatt-hour, a figure no central station can approach. Where a large part of the exhaust steam is used or where most of it is used in winter and little in summer, the year-round power-generation efficiency of the small isolated plant will in many cases exceed that of the central station.

19. A bigger flywheel increases (or decreases) the power of an engine.

The energy required to get a large flywheel up to speed and that which it will release in coming to rest lead some engineers to imagine that the flywheel increases the power of an engine and others to imagine that it decreases it. It does neither, except that a very heavy flywheel, by increasing the load on the bearings, may slightly increase the friction loss. Aside from this minor consideration, a flywheel is like a no-interest bank account which absorbs money at some periods and gives it back at others but neither *makes* nor *loses* money for the depositor.

20. Heat rises.

Hot air rises because it is less dense than colder air. Hot water rises in cold water for the same reason. On the other hand, ice rises in warm water and water at 33 deg. rises in water at 39 deg. All cases of heat "rising" are cases of convection in fluids that expand with rising temperature. Heat passing by true conduction or radiation shows no more preference for the up direction than any other. Heat will pass down a vertical iron rod exactly as well as up it.

New and Improved Equipment

The Arca Automatic Regulator

Automatic regulators have been devised for almost innumerable purposes, such as for the control of combustion, pressure, flow, temperature, humidity, etc., and new types are continually being developed. A type of regulator known as the Arca, which has a wide range of applications, has recently been introduced in this country. It was developed about six years ago by Ragnar Carlstedt, of Stockholm, Sweden, and is manufactured in this country by the Arca Regulator, Inc., Grand Central Terminal Bldg., New York City.

In this type a spring-loaded relay arm is balanced against boiler pressure on whatever medium is being regulated and a free flowing stream of water. Fig. 1 shows a section through a schematic arrangement of the regulator equipped to have the initial impulse given by a change in steam pressure. The regulator is also shown in Fig. 2 connected to control a reducing valve. *A*, Fig. 1, is the relay arm pivoted at *N* and throttles a jet of water at *L*. This arm is loaded by a spring *O* against steam pressure acting on the outside of a copper sylphon *B*. A pilot valve *P* is attached at one end to a diaphragm *D* and can move in either direction to open and close ports *K* to admit or discharge pressure water from the operating cylinder attached to whatever may be regulated. Pressure water flows into chamber *C* and then through the strainer *E*, through the center of the pilot valve *P* to chamber *F*, up through passage *H*, and holds relay arm *A* off the discharge end of this passage. The smaller the discharge opening between the end of arm *A* and the top end of passage *H*, the more restricted will be the flow and the greater the pressure will be in chamber *F* acting on diaphragm *D* to force the pilot valve to the left against spring *G*. When the relay and pilot valve are in a state of balance, the latter is in a position so that ports *K*, which admit or discharge water to or from the pressure cylinder, are closed and the whole regulating system is in a state of equilibrium. This is the position in which the pilot valve is shown in the figure.

Assume that the regulator is in a balanced condition and is operating a reducing valve and that a drop of pressure occurs on sylphon *B*, which is connected to the low-pressure side of the valve by pipe *Q*. This will allow springs *O* to start moving relay arm *A* downward and throttle the jet of water at *L*, causing the pressure in chamber *F* to build up and move the pilot valve to the left and open the left-hand end of ports *K*. This allows pressure water to flow from chamber *C* through pipe *L* into the operating cylinder, which in turn changes the position of the valve opening to restore the pressure in the pipe line. When the pressure has been brought to normal, the relay and pilot valve take a position to put the system in equilibrium and further motion of the regulator ceases.

With an increase in pressure above normal the relay arm is caused to rise slightly and allows the water jet to flow more freely. This will cause a reduction in pressure in chamber *F*, and the pilot valve will be moved to the right by the spring *G*, which will open the right-hand end of the ports *K* and allow water to flow from the operating cylinder to waste through pipe *M*, and the counterweight, Fig. 2, starts closing the value to bring the pressure to normal.

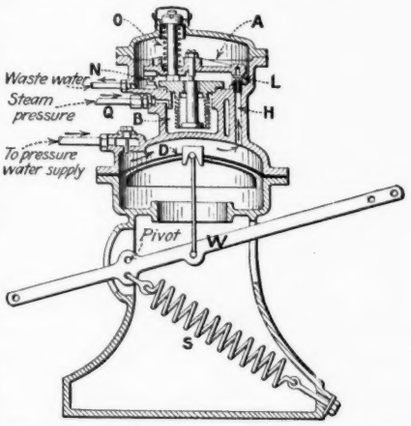
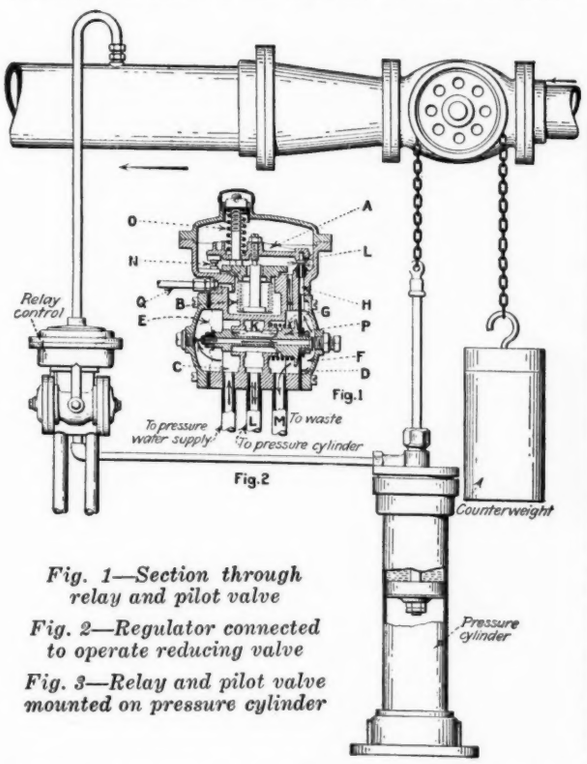


Fig. 4—Section through regulator for stoker and forced-draft fan control

In Fig. 2 the relay and pilot valve are shown separate from the pressure cylinders. However, with equipment of this type the relay and pilot valve may be mounted directly on the pressure cylinder as in Fig. 3.

Fig. 4 shows a diagram of a section through a regulator arranged for controlling the rate of fuel feed and forced-draft fan speed on a boiler. In this equipment pressure water is admitted into the chamber above diaphragm *D* and flows through passage *H* and out at *L* and then out through the waste-water pipe. This is essentially the relay in Fig. 1. Boiler pressure is admitted through pipe *Q* to act on sylphon *B*, so that steam pressure acts upward on the relay arm *A* in conjunction with the water pressure, this arm being loaded through spring *O*. To one end of lever *W* is attached the speed-controlling device for the forced-draft fan and to the other the stoker-feed control. With a drop in steam pressure sylphon *B* allows relay arm *A* to move down slightly and throttle the water jet at *L* and increase the pressure on diaphragm *D*, causing the right-hand end of lever *W* to move down and the left-hand end to move up. In doing this the tension in spring *S* is increased. This movement of lever *W* continues until the tension of *S* balances the pressure on diaphragm *D* when the regulator is in a state of equilibrium. This change in the position of *W* increases the speed of the stoker and forced-draft fan. An increase in boiler pressure causes sylphon *B* to raise arm *A* slightly and decrease the throttling effect on the jet



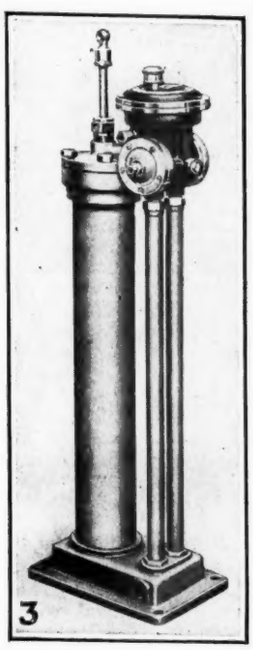


Fig. 1—Section through relay and pilot valve

Fig. 2—Regulator connected to operate reducing valve

Fig. 3—Relay and pilot valve mounted on pressure cylinder

at *L*. This allows the water to flow more freely and reduces the pressure on diaphragm *D*, which will allow spring *S* to move lever *W* in a direction to slow up the fuel feed and forced-draft fan. This operation continues until reduced tension in spring *S* balances the decrease in pressure on diaphragm *D* when the regulator is again in a state of equilibrium.

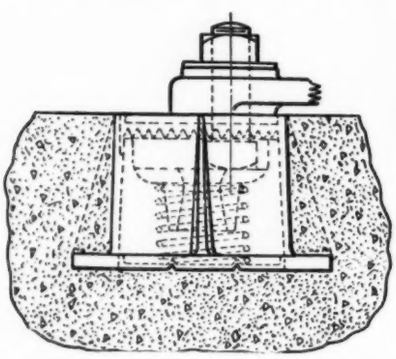
A device similar to Fig. 2 may be used to control the position of the stack

Fig. 5—Assembly of stoker and forced-draft fan regulator

damper or induced-draft fan speed from pressure over the fire, by substituting a sensitive diaphragm for sylphon *B*. By substituting appropriate devices for giving the initial impulse, the regulator may also be used for controlling temperature, humidity, vacuum, speed, etc.

New Adjustable Insert for Machine Mounting

For the purpose of fastening machinery or other equipment to concrete floors, walls or ceilings without the disadvantages attending the use of bolts embedded directly in the concrete, a new adjustable bolt insert has been



Insert embedded in concrete with bolt in adjusted position

designed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pennsylvania.

The adjustable insert consists of a cast-iron housing with a tapering body and containing a rotatable bolt carrier. The bolt carrier is T-slotted to take the head of a standard machine bolt and is of sufficient length to permit a ⅝-in. movement of the bolt from the center. Since the carrier can be rotated, the adjustment of the position of the bolt can be secured in any direction. The housing and bolt carrier are provided with teeth which mesh and prevent any change in position after the adjustment has been made and before the bolt has been tightened. The teeth are kept in mesh by a retaining spring which is held in by a sheet-metal plate at the back of the housing. The inserts are available for ⅝-in. and ¼-in. machine bolts.

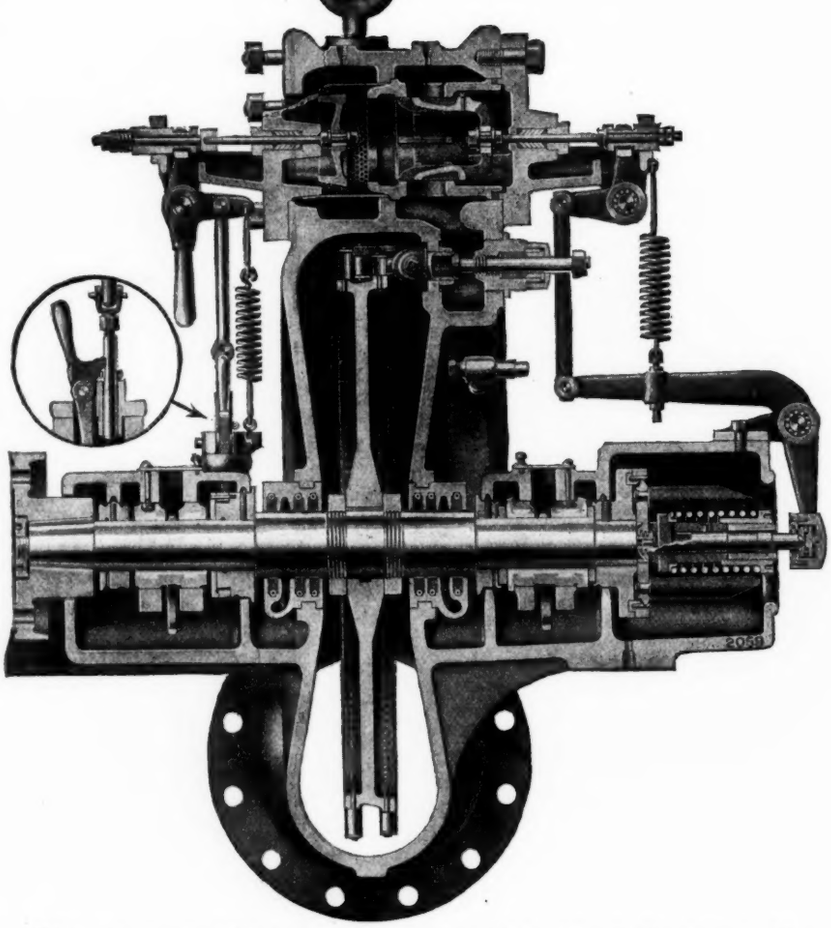
High Temperature Confined to Top of Turbine Casing

In the new design of the De Laval velocity stage turbine, built in capacities from 1 to 1,000 hp. and especially suited for high temperatures and pressures, the steel wheel casing is supported at the center by a single bearing pedestal. The bearing housings are integral with the casing as shown in the figure, so that positive alignment under all conditions is assured. The steam inlet and nozzle chamber are placed at the top of the wheel casing so that high temperatures and pressures are restricted to this location, the remainder of the turbine being under exhaust temperature and pressure. Steam enters the steam chest on the side away from the observer in the figure, passes through a strainer in the emergency valve compartment and thence directly to the throttling valve.

The globe-type emergency valve is entirely independent from the throttling valve, being closed by positive spring pressure as soon as the machine reaches a predetermined overspeed.

A novel feature in this machine is that each nozzle is connected to its accompanying stationary row of blades as a unit. The stationary blades may therefore be installed in direct proportion to the nozzles utilized. If the capacity of the machine is to be increased, each nozzle and its accompanying stationary blading to which it is attached may be installed as one piece.

The wheel is held by two locknuts on a rigid type shaft. Stuffing boxes, each containing three rings of carbon packing, are supplied at each end. Hand-operated nozzles may be regulated for obtaining maximum efficiency of operation at any desired load.



High pressure and temperature steam chest at top of velocity stage turbine

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One-third more electrical energy is now generated from a ton of coal than was produced five years ago in the central stations of the country, according to a recent survey of more than four thousand electric light and power plants by the Geological Survey.

Fuel Oils for Diesel Engines*

By D. AUFHAEUSER

The properties of Diesel oils are functions of their degree of distillation. Combustion is merely a fractional distillation. The present method of determining flash point is valueless as a guide in Diesel-engine operation.

LIQUID fuels may be divided into two general classes, those that are burned in furnaces and those that are used to drive engines. The latter may be reclassified into oils used in carburetor motors and those used in engines such as the Diesel.

By far the most important property is the fact that these fuels may be vaporized without disintegration. Certain solid derivations such as naphthalin, paraffin and anthracene may also be included, since these may all be melted and gasified without change in their composition

Combustion Processes

Every kind of combustion is purely a gas process, the differences being chiefly determined by the completeness with which the fuel is gasified or vaporized. In carburetor motors at ordinary temperatures the fuels gasify independently of their combustion. In Diesel engines gasification takes place only at high temperatures and immediately preceding combustion. In boiler furnaces an unstable oil gas is formed, accompanied by coke formation. The boiling point of an oil is all important. Thus carburetor motors require oils having a low boiling point, Diesel engines a medium and boiler oil a high boiling point. A low boiling point may be designated as 300 deg. F., medium from 450 to 575 deg. F. and high boiling point above 575 deg. It may be noted that boiling points between 300 and 450 deg. F., corresponding to that of kerosene oil, are of little importance as a power fuel.

The table shows the derivation and the uses of all important fuel oils from petroleum and anthracite tar. To a lesser degree other fuel oils are also obtained from brown coal tar. The raw anthracite tar is distilled in a similar manner as raw petroleum. All the fractional distillations are characterized by no sharp dividing line between them.

Anthracite Tar Products

Since the two original raw products, petroleum and anthracite tar, are entirely different in chemical composition and in physical properties different distillation processes are required. One difference is the fact that anthracite tar will invariably yield a solid residue, pitch, which is not suitable for combustion but is useful in the manufacture of briquets made from anthracite dust. The boiling temperature range of gas oil has been decreased to 350 deg., as gas oil, in contrast to kerosene, is growing rapidly in importance. The difference in the chemical composition of anthracite tar and petroleum products is of great influence in the process of combustion, as the history of the Diesel engine will show.

It is important to note that the anthracite tar products are "ring form" carbohydrates, similar to the benzol ring, or multi-rings, like naphthaline or anthracene. Their characteristic is the fact that the ratio between hydrogen or carbon is less than 1, as example:

Benzol.....	C_6H_6.....	H:C = 1:1
Naphthaline.....	$C_{16}H_{10}$.....	H:C = 0.8:1
Anthracene.....	$C_{14}H_{10}$.....	H:C = 0.7:1

Petroleum products are "open" or "chain" form carbohydrates of the general composition, $C_nH_{(2n+2)}$. The ratio of hydrogen to carbon, being (2n+2) ton, approaches 2.

Motor oils distilled from brown coal tar are entirely different in chemical composition from anthracite tar products, but bear a stronger resemblance to those obtained from petroleum. Brown-coal tar oil was called "gas oil" even before the Diesel engine was of practical importance. The difference between fuel and motor oil is, therefore, chiefly determined by their boiling points and may be further divided by their derivation from anthracite tar or from petroleum and brown coal tar.

Desirable Properties

Certain properties are important for the Diesel oils. The many methods in use for analyzing and testing the oils are apparently very confusing. The situation is clarified, however, by abandoning the comparison with solid fuels and grasping the fundamental fact that liquid fuels are mixtures of carbohydrates, of forced chemical combination, and as such, their properties show definite relations.

The ease with which the oils may be distilled is of major importance, the quality of an oil being determined by the quantity of distillates having a boiling point up to 575 deg. F. The best petroleum gas oils will yield 90 per cent and the best anthracite tar oils at least 60 per cent. The best Diesel oil is invariably that which shows the most regular curve in boiling points between 450 and 575 deg. F. All other properties are of minor importance. For instance, a high heating value does not signify excellence if the distillation is unfavorable. But such a condition does not exist, as there are fixed relations between the distillation and other properties which make it a simple matter to determine the true value of an oil. The heating value of petroleum gas oils is always a value as high as 18,500 B.t.u. per lb. Anthracite tar oils have heating values from 16,500 to 17,300 B.t.u., and may be considered as intermediate. With similar oils these fixed values may determine their relative quality provided the judgment is backed by experience and knowledge which justifies the conclusion. It must be remembered, however, that for Diesel engines the value of a fuel oil is determined chiefly by its distillation process.

Flash Point Important

The flash point deserves considerable attention. This temperature, as determined in either open or closed vessels, is that at which the first ignition occurs. It shows when slight gasification occurs, but is lower than the temperature at which the oil actually catches fire. The condition inside of the Diesel engine cylinder are entirely different, because the air is under a pressure of 30 atmospheres or more, which is to produce spontaneous ignition and combustion of the vaporized oil. The high pressures demand that the flash point of the oil should be at least 500 deg., since the high pressure opposes vaporization of the oil.

Spontaneous Combustion

With spontaneous ignition dissociation of the oil takes place just previous to combustion, which gives up heat. This phenomenon has played an important part in the first attempts to utilize anthracite tar oils in Diesel engines. It occurs differently with the three kinds of oil, and this difference may be explained by the fact that the atomic open or chain form hydrocarbons of petroleum and paraffin oils is much more easily broken up than the atomic ring form of the hydrocarbons in anthracite tar oils. Such a breaking up is, however, necessary to bring about spontaneous combustion within the cylinder. The actual ignition is brought about partly by the compression and partly by the heat given off by the dissociation process, together with the catalytic influence of the hot metal. Such catalytic action by highly heated metal is known to occur during the combustion of all gases, and therefore this action within the cylinder is of greater importance than has hitherto been assumed.

The differences in flash points of the oils are, therefore, due to their chemical compositions. This has been recognized and has been applied in practice by the admission of a quantity of light

TABLE I—KIND AND USE OF DISTILLATES OF PETROLEUM AND ANTHRACITE TAR

Origin	Distilled Products: Light (For Carburetor Engines)	Distilled Products: Medium (For Diesel Engines)	Distilled Products: Heavy (For Diesel Engines)	Residue: Boiler Oil (For Furnace Firing)	Residue:
Petroleum	Benzine to 300 deg. F., spec. gravity 0.7 to 0.75	Kerosene 300 to 450 deg. F., spec. gravity, 0.80 to 0.83	Gas oil 450 to 575 deg. F., spec. gravity 0.85 to 0.88	Boiler oil (Masut in Russia) (Pacura in Rumania)	
Anthracite Tar	Light raw benzol to 170 deg. F. spec. gravity 0.91 to 0.96	Medium 170 to 230 deg. F., spec. gravity 1.02	Heavy 230 to 270 deg. F., spec. gravity 1.05	Anthracene 270 to 350 deg. F., spec. gravity 1.10	Pitch Soft, medium or hard; as binder for anthracite briquets

*Extracted from *Zeitschrift des Vereines Deutscher Ingenieure*, March 1, 1924.

"ignition oil" for starting purposes. The ignition points that have been determined by present methods, lie usually between 170 and 230 deg. F. for Diesel oils. These values do not reveal anything definite regarding the action within the cylinder. For instance, a petroleum gas oil with a flash point of 230 deg. will ignite more readily within the cylinder than an anthracite tar oil with a flash point of only 170 degrees.

The sulphur content of these oils usually is below 0.5 per cent. Even if the crude oil contains a large amount of sulphur, most of this associates itself with the heavier products. In spite of this fact some Diesel oils may contain 1 per cent or more of sulphur. This is particularly true in the case of petroleum oils.

Insoluble elements that cannot be classified as carbon, should be present only as a trace, otherwise the requirements for proper distillation cannot be fulfilled. Not more than 3 per cent should be present in the residue.

Well-distilled motor oils contain only an imperceptible trace of incombustible matter. The ash, which is mostly caused by foreign substances such as tank rust, etc., amounts to between ½ to ⅓ of 1 per cent.

Small Amount of Water Not Objectionable

The water contained in petroleum gas oil is 0.5 per cent and amounts to 1 per cent in anthracite tar oil. Such small amounts of water are not objectionable. Furthermore, it is impossible to obtain commercial oils entirely free from water. In some cases a small amount of water may even have a favorable catalytic effect.

Ash is the only incombustible in oil. Therefore, if a residue appears within the cylinders, it is safe to say that this is comprised of elements that are difficult to ignite. These consist principally of some form of decomposed hydrocarbonates and coke.

In addition certain chemical compounds, the presence of which is not always correctly interpreted, may be mentioned. In the case of petroleum oils asphalt may be referred to as such. This term is supposed to include substances rich in oxygen which are formed by oxidation in the crude oil. These are not distillable, and if present in larger quantities, the oil becomes unsuitable for Diesel engines because complete combustion is impossible.

Petroleum gas oil, as a distilled substance, cannot contain asphalt. It is true, however, that a very small amount of oxidation takes place in a petroleum oil, which causes the oil to become darker in color. However, the amount of asphalt formed is negligible and is readily broken up by the heat within the cylinder. The amount of asphalt in crude oil varies so greatly that it is necessary to determine individually whether an oil is suitable for Diesel engines or not. This question is of particular importance in the marine field. The decision here rests with how much asphalt is permissible in the oil.

Brown-coal tar oil contains a desirable substance, paraffin, which is advantageous to Diesel engine consumption. Paraffin does not vaporize under 575 deg. F., and for this reason brown-coal tar oil cannot contain more than 10 to 12 per cent of it.

Creosotes are also contained in brown-coal tar oil, but their slight acidity is of no consequence to the Diesel cylinder. An important detriment is the fact that they contain much oxygen. Such substances burn poorly because a large part of their oxygen appears in the form of hydroxides and is not available for active combustion. The carbo-hydrates rich in oxygen break up into complex compounds and hinder efficient combustion. Brown-coal tar oils with a high creosote content are, therefore, unsuitable for Diesel engine combustion. The permissible amount of creosote has not yet been specifically determined, but it may be said that 8 to 10 per cent is hardly objectionable.

Anthracite tar oils contain similar acidulous creosotes, but in lesser quantities. They mean nothing to the Diesel engines, because there is a ready chemical market for these and they are removed when the tar is distilled. Their temperature range of distillation lies somewhere between that of light and medium oils. The naphthaline and anthracite content is of much greater importance. Naphthaline, with a melting temperature of 175 deg. F. and a boiling point of 430 deg. F., is found principally in medium oil, whereas anthracene, with a boiling point of 660 deg. F. is found in the heavy oil and in anthracene oil. Both substances make their presence known by the formation of crystals. The degree of crystallization is due to decreasing solubility with falling temperature. A noticeable difference exists between summer and winter. Specifications therefore read that no crystallization shall appear at a temperature between 5 and 10 deg. C. A slight precipitation of anthracene at low temperature is not objectionable, since this will disappear when the temperature is raised.

Naphthaline is even less troublesome. Too great saturation with anthracene, which may be the result of too extended preheating should be avoided because anthracene will burn into products that are poor in hydrogen only when it is dissolved in a surplus of anthracite tar oil. Anthracene alone, as well as its various derivatives, cannot be burned within the Diesel engine cylinder. Even naphthaline causes trouble in this regard, for while its high vapor pressure and low boiling point are favorable, the chemical composition is detrimental to the engine.

Distribution of Electric Energy in Italy

Of a total of 9,225 Italian communes, including the provinces annexed after the war, 4,943 possess electric generating stations, while 4,282 are not so provided, according to statistics as of Dec. 31, 1923, published in the May issue of *L'Impresa Elettrica* and republished in *Commerce Reports*. Of those possessing stations, 4,693 are furnished with energy by private power companies, while only 250 have stations which are operated by the communes.

The following figures serve to demonstrate the progress that has been made in electrical distribution in the northern provinces as compared with those of the South:

	Per Cent
Northern Italy and new provinces	83.78
Central Italy	83.60
Southern Italy	60.75
Sardinia	24.30
Sicily	52.35

Basing its calculations on the old census giving the total population of Italy as 36,204,182, 23.70 per cent, or 8,585,683 inhabitants, are still unable to enjoy the use of electric energy.

Steel Corrosion Tests by Ultra-Violet Rays

In recent tests made in the Bureau of Standards, the effect of ultra-violet rays upon polished metal surfaces was observed by allowing the rays to play upon a small area of the surface, the remainder of the surface being shielded by a thin metal sheet. Specimens of Armco iron, medium-carbon steel, "stainless" steel and high-nickel steel were exposed for 18 hours to the ultra-violet rays, the result being a pronounced change in the exposed area. When the specimen is cooled and the moisture of the breath is allowed to condense on the surface, the exposed area becomes visible at once, the drops of condensation being larger than on the unexposed parts and the surface looking as though a thin film of oil had been spread over it so that it is not wetted so easily as the rest of the surface. In the medium-carbon steel, very noticeable corrosion of the exposed spot occurred after four condensations of moisture, while the remainder of the surface was hardly attacked. Chromium and nickel steels did not show any corrosion, although the same difference between exposed and unexposed areas was noticed.

United States Exports of Coal and Petroleum

United States Department of Commerce

	Month of June		12 Months Ended June	
	1923	1924	1923	1924
Coal:				
Anthracite, tons	418,594	349,134	3,733,714	3,930,794
Anthracite, dollars	4,504,939	3,785,798	40,691,885	43,173,035
Bituminous, tons	2,418,769	1,513,899	15,953,879	17,200,245
Bituminous, dollars	12,653,967	6,145,836	97,623,225	85,160,910
Coke, tons	63,841	48,238	967,272	713,546
Coke, dollars	680,325	391,569	10,645,522	6,582,238
Petroleum:				
Crude, gallons	108,071,490	63,718,297	552,566,487	784,594,472
Crude, dollars	3,569,971	2,460,145	20,268,679	26,342,596
Total refined petroleum, gallons	269,557,001	360,173,502	2,820,461,506	3,643,516,248
Total petroleum, dollars	29,368,451	39,142,722	324,723,878	356,658,290
Gasoline, naphtha and other light products, gallons	70,897,665	111,734,237	674,716,726	1,031,610,456
Gasoline, naphtha and other light products, dollars	12,676,963	17,947,380	134,165,991	150,667,895
Oils:				
Gas and fuel, gallons	96,156,422	133,706,470	937,243,885	1,361,122,655
Gas and fuel, dollars	2,708,574	4,703,819	29,687,604	41,613,640
Lubricating, gallons	38,364,462	33,256,702	353,937,284	368,180,263
Lubricating, dollars	7,818,589	8,175,622	78,893,622	83,860,35

One Hundred and Seventy Thousand Coal Cars Idle

The Car Service Division of the American Railway Association called attention to the fact that the railroads on July 28, had nearly 170,000 surplus coal cars in good repair and immediately available for service but that they were not in use owing to the lack of demand for fuel.

Coal production so far this year has fallen below the corresponding period in 1923, bituminous production alone up to July 12 having been more than 51,000,000 tons below that for the same period in 1923.

New Zealand Power Scheme Started

It has recently been announced in Wellington, New Zealand, that the contracts had been awarded by the government for the dam, spillway, headworks and power house of the New Zealand government's scheme for the development of electric power at Arapuni. According to information furnished *The Engineer*, the power house will primarily be equipped with three turbine sets of 25,000 hp. each, working under a head of 175 ft. and generating three-phase current at 6,600 volts for distribution by several feeders. The headwork will require the tunneling of a mountain and will include three penstocks 12 ft. in diameter.

Lamme's Will Provides Engineering Awards

Provision for two scholarships in mechanical and electrical engineering and for the establishment of several annual awards for graduates of engineering schools and others for work looking toward the advancement of knowledge and accomplishment in those fields is made in the last will of Benjamin G. Lamme, former chief engineer of the Westinghouse Electrical & Manufacturing Co.

A trust fund of $15,000 was set aside to provide for two scholarships for the two most capable students in electrical and mechanical engineering respectively at Ohio State University.

Three medal awards are provided for in the will. A fund of $6,000 was established for gold medals to be awarded annually to graduates of one of the technical departments of the Ohio State University for meritorious achievements in engineering or technical arts. Two other funds of the same amount were created to recognize the accomplishments of technical teachers and of members of the American Institute of Electrical Engineers.

Canadian Bureau of Mines Starts Research Program

The Canadian Department of Mines, division of fuels and fuel-testing will have on its program of reseach: An analysis of western coals; domestic heaters; domestic coke; carbonization of different classes of fuels; gasoline; lubricating oils; motor spirits by the Ramage process; oil shale.

Shawmut Plant Purchased by Central Maine

One of the most important transactions that have taken place in water-power property in Maine for a long time was completed recently when the Central Maine Power Co. signed a contract for the purchase of all the capital stock of the Shawmut (Me.) Manufacturing Co.

The property of the Shawmut company includes a modern concrete power house containing 6,000 hp. of hydro-electric machinery, together with the so-called Shawmut dam situated on the Kennebec River at Shawmut.

Since this power house and dam were built, eleven years ago, the Central Maine Power Co. has bought from it 2,000 hp. annually. The Shawmut company has also sold power to the Keyes Fibre Co., which owns a ground wood pulp mill located on this property.

With complete control of the plant the Central Maine Power Co. will be able to make full use of all the power available at this dam except that used under the contract with the Keyes Fibre Co. With but little outlay the capacity can be increased to 10,000 horsepower.

The present Shawmut Dam is the longest dam on the Kennebec River. It extends the entire width of the river, which is 1,140 ft. at this point. The operating head is 21 ft. Here the Kennebec provides almost a natural reservoir throughout for 11 miles back to what is known as the Mill Pond in Skowhegan, which is back of the supply for this development at Shawmut.

By securing this dam at this particular location, the power company obtains complete control of the water discharged from its recent new development at Skowhegan to the outskirts of Waterville. This control will enable the company to improve the efficiency of the two plants.

While Central Maine Power Co. does not contemplate any immediate extensive changes, it will have recourse to this important link in its present developments along the Kennebec to secure a more steady supply of power and to develop additional power as the demands of Maine industries and homes may warrant.

Power Machinery Exports to Australia Increase

According to *Commerce Reports* American exports of power-generating machinery to Australia amounted to $348,732 in 1923—an increase of nearly $90,000 over the 1922 figure. The United States shares with the United Kingdom the bulk of the trade in motive-power equipment, there being an almost total absence of continental imports of power-generating machinery and equipment. The United Kingdom furnished 99 per cent of the boiler requirements of Australia. Practically all Diesel-engine shipments originated in England. The United States supplied about 36 per cent of the lighter internal-combustion engines purchased during the year.

In the miscellaneous machinery classification the greatest increase occurred in exports of refrigerating and ice-making equipment, which rose from $37,661 in 1922 to $105,761 in 1923.

Corrosion Causes Smokestack To Fall, Killing Four

The top section of a heavy smokestack belonging to the Charlevoix Building on West Elizabeth St., Detroit, Mich., fell and killed four and injured two others who were in an automobile passing through the street at 7 o'clock on July 23. The section that caused the fatalities weighed about ten tons and was steel-jacketed.

In a preliminary investigation the buildings inspectors found that the pipe was full of rust holes, one of which was large enough for the insertion of a man's fist. It was also reported that the steel of the smokestack was $\frac{3}{8}$ in. in thickness joined with $\frac{3}{4}$-in. rivets, around which corrosion had attacked the metal. The part of the stack that fell measured 25 ft. in length and was about 10 ft. in diameter. Two other sections of the pipe fell, but it was the steel-jacketed portion which caused the death, and injuries and wrecked the two automobiles. The stack is about 15 years old and is of the old-fashioned type, built outside the building. It was heavily laden with soot.

The coroner advanced the opinion that there probably was an accumulation of gas and as the pipe had become clogged with soot, and consequently the gas, having no outlet, exploded, throwing the top of the stack far off center and tipping it. There was no appreciable breeze at the time of the accident.

There does not appear a record of an inspection of this smokestack as the building code does not call for periodical inspection of such chimneys, in the city of Detroit.

Fond du Lac Project Starts First Unit

The first unit of the Minnesota Power & Light Co.'s new $5,000,000 hydroelectric development on the St. Louis River at Fond du Lac, Minn., has been put in operation. This first unit has a capacity of 15,000 hp., and provision has been made for the installation of an additional 15,000-hp. unit as soon as needed. The dam is 600 ft. long and 85 ft. high at its highest point.

Canadian Scholarships Offered

According to the *Christian Science Monitor*, the Canadian-Pacific Railway has offered three scholarships in the University of Montreal for apprentices and minor employees, two covering four years' tuition in civil, mining, chemical or electrical engineering, and one three years in commercial courses. The company some time ago offered similar scholarships in McGill University for English-speaking apprentices.

Italian Electric Power Companies Prospering

The situation in the electrical power industry in Italy is satisfactory, according to the report of the directors of the Association of Electric Power Companies. Conditions during 1923 are said to have been favorable and the electric companies have been able to increase their activity through the financial support they have received from the investing public. The construction of new plants is proceeding rapidly, and the opinion is expressed that within six or seven years it will be possible to satisfy a consumption double that of the present time. By the use of electric power Italy is saving annually about 1,500,000,000 lire which otherwise it would have to pay for imported coal. The government, through taxation, is also receiving annually a sum equal to about 9 per cent of the capital invested in electric plants, which is in most cases more than is received by the stockholders in dividends.

Engineering Students To Go on Shipping Board Boats

The following order, providing for student engineers on Shipping Board vessels has been issued by the operating department of the Fleet Corporation:

Students in engineering may be carried on vessels if there are living quarters available. Such students will be signed on as cadet engineers at the nominal rate of 25 cents a month and will mess with engineer officers.

Applicants for positions as cadet engineers must have certificates from the authorities (preferably the presidents) of the institutions they are attending, stating that they are bona fide students and that there is an educational benefit directly connected with their technical courses to be obtained from practical experience in the engine rooms of vessels.

While applications will be transmitted by district directors to the operating department at Washington for approval, advance authority may be obtained by wire or telephone.

In the interest of students consideration is to be given to the length of voyages in relation to the dates they must be back for their studies.

The intent of this order is to afford those pursuing technical courses in engineering opportunity to obtain the benefits of practical experience. It is not the intent to make cadet engineers a permanent rating.

Federal Power Commission Received 512 Applications

During the fiscal year ended June 30, the Federal Power Commission received 87 new applications for rights under the act. Of these 34 were for preliminary permits and 53 were for licenses. Of the licenses 10 were for major projects. During the fiscal years 9 holders of preliminary permits applied for license.

At the end of the fiscal year, the total outstanding rights asked of the Federal Power Commission covered 21,500,000 hp., the total estimated installed capacity of the projects and the proposed projects. The total is practically the same as was the case at the end of the fiscal year of 1923 and of 1922. In all the total of 512 applications have been filed with the Commission, but some of them have been rejected and others have expired, thereby offsetting the additions represented by new applications. During the fiscal year just ended, the new applications covered projects with an estimated installed capacity of 2,500,000 hp., but the losses resulting from rejections and expirations totaled that amount.

Practically one-half of the 21,500,000 hp. represented by the existing live applications cover projects on the St. Lawrence, the Colorado and the Columbia, which are being held in abeyance on questions of policy. The St. Lawrence is an international stream and the plan for its full development must be worked out with Canada. No licenses are being granted on the Colorado, pending the ratification of the Colorado River compact or some other agreement between the states of the Basin. On the Columbia the plan for the river's development is awaiting the determination of the feasibility of the Columbia Basin project.

The expiration date of an unusually large number of preliminary permits will occur during the current fiscal year. In many instances, it is anticipated that application will be made for licenses, but in others it is known that the requirements of the preliminary permit are not being complied with.

During the past fiscal year, ten of the licenses issued were for major projects, principal among which are: the Columbia Valley Power Co.'s project on the Deschutes River, where an installation of 185,000 hp. is to be made; the Upper Tallapoosa where 114,000 hp. will be installed; the Pike Rapids Power Co., on the upper Mississippi, 24,000 hp., and the Thomas Bay project in Alaska, 29,000 hp.

Exposition of Chemical Industries in 1925

The Tenth Exposition of Chemical Industries will be held during the week of Sept. 28-Oct. 3, 1925, at the Grand Central Palace, New York City. F. W. Payne and C. F. Roth, who have been studying conditions and possibilities for chemicals in Europe, the West Indies, New England and the Atlantic States, report that much interest is being shown in the Exposition plans.

Westinghouse Announces Scholarship Winners

The winners of the four War Memorial scholarships, annually offered by the Westinghouse Electric & Manufacturing Co., were announced on July 10. Each scholarship carries with it $500 a year for four years, to be devoted to engineering education in an approved technical school or college. The scholarships were awarded this year to Homer C. Porter, Pittsburgh, Pa.; Robert W. Richards, Pittsburgh, Pa.; Robert E. Patterson, Wilkinsburg, Pa.; and Samuel D. Reynolds, Rutledge, Pa.

Dynamometer Engineer for Bureau of Mines

The United States Civil Service Commission announces the following open competitive examination for dynamometer engineer:

A vacancy exists in the Bureau of Mines, at San Francisco, Calif. The entrance salary is $3,800 a year. Advancement in pay may be made without change in assignment up to $5,000.

Applicants must have been graduated from a college or university of recognized standing with a degree in mechanical or electrical engineering. In addition, they must have had at least six years' practical engineering experience, of which two years must have been in a responsible position in development testing of internal-combustion engines, involving a thorough knowledge of thermodynamics, as well as the practical operation of the engine and dynamometer.

The duties of the position require that the appointee be a highly skilled engineer with ability to assemble properly, set for tests, and operate internal-combustion engines at as near uniform efficiency as is possible.

Competitors will not be required to report for examination at any place, but will be rated upon their education, training and experience, and upon a thesis which must be filed with the application. Receipt of applications will close Sept. 2, 1924.

A Correction

In the June 3 issue of *Power*, page 925, it was announced that Columbia College had abolished its six-year courses in engineering. This statement was erroneous as that action had not taken place but was only being discussed. Columbia College still has six-year courses in civil, mechanical, mining and chemical engineering.

Southern California Edison Adds Steam Equipment

The Southern California Edison Co., in an effort to meet the emergency caused by the water shortage in California, has placed in service a total of 26,620 hp. in steam capacity in the form of small or obsolete plants which have been leased from industrials in southern California. In addition one 13,000-hp. turbine has been purchased and installed in record time in the Long Beach steam plant and two 6,500-hp. turbines which were supplied by Eastern manufacturers were placed on the line on July 15. Work is progressing rapidly on the Long Beach No. 2 steam plant, which will have a capacity of 93,000 hp., and which will probably be in operation by the first of next year.

Neither of two plants which have been leased from the Pacific Electric Co., has been in operation for ten years. In addition energy is being purchased from the following: Los Angeles Gas & Electric Corp., 33,000 hp.; City of Pasadena, 13,000 hp.; San Diego Consolidated Gas & Electric Co., 5,300 hp. —totaling 51,300 hp.

A contract has been made with the San Joaquin Light & Power Corp., Fresno, to deliver 16,500 hp. beginning Aug. 1. Further relief will also be had through an arrangement whereby the Pacific Gas & Electric Co. and the Great Western Power Co. will divert their excess power to southern California in order to relieve the power shortage caused by drought conditions there. This plan has been approved by the State Railroad Commission.

Power and Navigation Will Go Together on St. Lawrence

Some extracts quoted from a letter written recently by the Chief of Engineers in response to an inquiry as to the cost of deepening lake harbors have been interpreted as indicating General Taylor's opposition to the St. Lawrence project.

Briefly summarized, the letter goes into the question of materials of the bottom of the harbors and of the Great Lakes and the economic consideration of deepening the St. Lawrence. It was not General Taylor's understanding, when he wrote the letter, that the inquiry dealt in any way with the St. Lawrence improvement. He set forth his position on the improvement of the St. Lawrence by saying that sooner or later the St. Lawrence will be developed for power and navigation purposes, that the demand for the river's power resources will eventually become so insistent that it cannot be resisted. When that time comes, the added cost of the navigation project would be a small additional amount, so that it would be natural that the river would not be developed for power purposes alone. The two are certain to go hand in hand. On the other hand, there could be no thought of carrying out the navigation project without the development of the stream's power resources. To determine the exact time when these developments should go forward, depends on an economic survey.

Report by Army Engineers on Chicago Diversion

A full statement of the diversion of Sanitary District of Chicago has been prepared by Maj. Rufus W. Putnam, Corps Engineers, U. S. A., district engineers, U. S. Engineers Office at Chicago. The report which was prepared in 1923, has only recently been made public. It is being printed and should soon be available for distribution. Some conclusions given are as follows:

"This diversion has lowered the levels of the Great Lakes and connecting channels to the positive detriment of navigation interests.

"This diversion permanently decreases the amount of water power available to the nation, not an insignificant loss at the present time but of large proportions in the future."

N.A.S.E. Program of Technical Papers

The program of technical papers of the national convention of the N.A.S.E. which is to be held at Grand Rapids, Mich., Sept. 8 to 13 is as follows:

"Twoscore Years of Power Development," by Fred R. Low, president of A.S.M.E. and editor of *Power;* "Applications of Pulverized Fuels in Power Plants," by Frederick A. Scheffler, Fuller-Lehigh Co.; "Automatic Combustion Control Systems," by Charles H. Smoot, Smoot Engineering Corp.; "Large Unit Boilers Operated at High Ratings," by Dr. Edgar Kidwell, Kidwell Boiler Co.; "New Type Synchronous-Induction Motors," by Val A. Flynn, consulting electrical engineer; "The Diesel as a Prime Mover," by Lacey H. Morrison, assistant editor of *Power;* "The Diesel Engine Power Plant," by Louis R. Ford, Morse Dry Dock & Repair Co.; "Boiler Room Instruments," by E. G. Bailey, Bailey Meter Co.; "Recent Developments in Ice-Making and Refrigerating Plants," by Halbert P. Hill, consulting refrigerating and electrical engineer; "Electrically Operated Flow Meters," by J. M. Spitzglass.

There will be an illustrated session on Tuesday evening. Charles M. Ripley will give the illustrated lectures, "2,500 Miles Across Europe in Passenger Airplanes," and "Labor and Horsepower Here and Abroad." There will also be three reels of motion pictures, "Revelations"; "The Busy-Body"; "The Light of a Race."

Decline in Production of Crude Oil in California

State Oil and Gas Supervisor R. D. Bush reports that production of crude oil in California for the first half of the current year was 118,113,000 bbl., compared with 146,338,069 bbl. in the last half of 1923, a decline of 28,225,000 bbl. Average daily production Jan. 1 was 700,300 bbl., declining to 619,500 bbl. on July 1, and shows steady decline from peak in the fall of last year.

While production decline has been gradual, the slump in the three big fields of Los Angeles basin, which produced the major portion of the oil, has been marked. Consumption also declined, but more rapidly than production, with the result that storage increased from about 92,000,000 bbl. on Jany. 1, 1924, to 100,000,000 bbl. at the end of June.

Denmark's Power Stations Increase

According to recent press reports it was stated at the annual meeting of representatives for Danish electric power stations that there were now about 500 electric power stations in Denmark (against seven in the year 1900); the production of electric energy in the financial year 1921-22 amounted to 208,000,000 kw.-hr.; the cost of the works aggregated 23,000,000 kroner; the gross revenue for the year in question was 78,000,000 kroner, and the net profits 23,000,000 kroner, or 10 per cent of the cost.

Power Merger to Develop Grande de Charge

Through the incorporation of the Duke-Price Power Co., Ltd., with a capital of $1,500,000, definite form was given to the joining of the J. B. Duke interests of New York and the Price interests in Canada, which have been working together in the Chicoutini and Lake St. John districts. The purpose of the incorporation is to develop and dispose of electricity in that part of Quebec.

It is understood, according to press reports, that the principal source of the power will be at the $25,000,000 development in progress at the Grande de Charge, where the work is being conducted through the Quebec Development Company.

Water-Power Projects

Kawishiwi River Project.—A license was granted by the Federal Power Commission to the Minnesota Power & Light Co., for the period terminating Oct. 26, 1973, for a constructed power plant on the Kawishiwi River, in St. Louis and Lake Counties, Minn. The project is between Gurden and Fall lakes and consists of a dam and dikes formed by the reservoir, a power house containing direct-conected, turbine-driven generating units of approximately 54,000 hp., penstocks about 375 ft. long connecting the dam and power plant.

Bartlett's Ferry Project.—The Federal Power Commission gave to the Columbus Electric & Power Co. a license for 50 years, for a power project at Bartlett's Ferry in the Chattahoochee River between Georgia and Alabama, and about 18 miles above Columbus. It consists of a dam about 115 ft. high, creating a storage reservoir of about 120,000 acre-ft. and making available an average head of 112 ft. The power capacity of the project is estimated to be 28,160 hp., and the proposed ultimate development will be about 80,000 horsepower.

Sicily Plans New Hydro Development.—Work has been going on for some time on a hydro-electric plant at Piano dei Greci in the mountains near Palermo, which is now in operation, and the water impounded primarily for the production of power will also be utilized for irrigation. A more extensive project is that for damming the Simeto River, which rises back of Mount Etna and flows through the plain of Catania. Final action in this connection is expected in the near future, according to *Commerce Reports*.

Saluda River, S. C., Project.—The Lexington Water Power Co. has applied to the Federal Power Commsision for a license to construct a dam about 100 ft. high in the Saluda River at a point about a quarter of a mile below the mouth of Bear Creek, near Lexington, S. C. A reservoir storing twelve billion cubic feet of water will be created. The power house at the dam will contain four units of electrical equipment, with a total capacity of 45,000 hp. This project will be tied in with the Santee-Cooper Rivers project.

Santee and Cooper Rivers Project.—The Federal Power Commission has authorized the issuance of a license to the Columbia Railway and Navigation, to whom a preliminary permit was issued Sept. 20, 1921, covering the project on the Santee and Cooper Rivers. The project contemplates the construction of a diversion dam in the Santee at Ferguson, the digging of a 14-mile canal easterly into the basin at the head of Cooper River, the construction of three or more earthen dams to create an equalizing reservoir and the construction of a power house and tailrace discharging into Cooper River at a point 25 miles above Charleston, S. C.

The development will be made in two stages. In the first stage the water will be impounded to a level of 55 ft. above sea-level and in the second stage the dams will be raised ten feet. It is estimated that 42,000 hp. can be developed initially and that the ultimate stage will develop 122,000 hp. The canal will follow the route of a pre-revolutionary navigation canal. When locks are provided, it will shorten the water route from Columbia to Charleston by 75 miles. The license will require the applicants to construct a lock in the diversion dam at Ferguson and that a discharge at that point be permitted so as to maintain a depth of six feet in Santee below the diversion dam. The Foundation Company, of New York, has undertaken to finance and construct the project.

Society Affairs

The British Association for the Advancement of Science which is holding its meeting this year in Toronto, Canada, Aug. 6-13, will have two papers of interest to *Power* readers: "Liquid and Other Fuels"; "A Hundred Years of Electrical Engineering," by Prof. G. W. O. Howe.

The American Chemical Society will hold a round-table discussion on the "Storage of Coal and Spontaneous Combustion," at its coming meeting, which will be held at Ithaca, N. Y., Sept. 8-13. Dr. S. W. Parr, of the University of Illinois, will lead the discussion. R. T. Haslam, M.I.T., is chairman of the Gas and Fuel Section.

Personal Mention

Martin J. Insull has recently been elected president of the Middle West Utilities Co.

Howard P. Quick, consulting engineer for steam and water power plants, has changed his office from 35 Nassau St. to 150 Broadway, New York City.

John C. McCabe, city research engineer of Detroit, Mich., has resigned that position and Joseph S. Stringham has been appointed to succeed him.

Thomas Brush, formerly chief engineer of the Plaza Hotel, New York City, is now employed at the Palmer House, Chicago, Ill., in the same capacity.

Dean M. E. Cooley has been appointed by the American Engineering Council as its representative at the Centenary Celebration of the Franklin Institute of Pennsylvania, to be held in Philadelphia, Sept. 17-19, 1924.

Col. William Kelly, chief engineer of the Federal Power Commission, is conferring with Canadian engineers with regard to some of the problems involved in the St. Lawrence superpower survey. On his return from Canada he will look over some of the power projects in New England, New York and Pennsylvania which would form a part of a superpower system.

Obituary

John H. Dunlap, Secretary of the American Society of Civil Engineers, died on July 29 as a result of the injuries he received in a railroad wreck a month ago, when he was returning with some other engineering professors from the meeting of the Society for the Promotion of Engineering Education at Boulder, Colo. President McNair of the Michigan School of Mines and Professor Ives, of the Ohio State University, were also killed in this wreck.

F. Loweth, past president of the society, accompanied the body to Franklin, Vt., where funeral services were held, July 31.

Mr. Dunlap had been secretary of the Am. Soc. C. E. for two years, having been elected during the annual meeting at Portsmouth, N. H., June, 1922, leaving the position of professor of hydraulics and sanitary engineering at the State University of Iowa, Iowa City.

Mr. Dunlap was born at Harrisville, N. H., Sept. 9, 1882. He was graduated from the Thayer School of civil engineering at Dartmouth College in 1908 after receiving his A.B. degree at that institution in 1905. After graduation he joined the faculty of the State University of Iowa as instructor in descriptive geometry and was promoted until he became professor of hydraulics and sanitary engineering.

Charles F. MacGill, for many years a prominent mechanical engineer in the United States and Canada, died at Boston, Mass., July 27, at the age of sixty. He was a native of Keeseville, N. Y., and received his early engineering training in the shops at Burlington, Vt., and in the copper mines of Michigan. For a time he was connected with the Westinghouse Agricultural Works at Schenectady, and for twelve years he was employed at the Schenectady and Pittsfield works of the General Electric Co. For five years he was manager of the Peterboro, Ont., works of the Canadian General Electric Co. He then went to Quebec as works manager of the Carrier Laine Co., marine engineers and boat builders, and followed this by a term of service as works manager of the Diesel Engine Co., St. Louis, Mo., where he built some of the first internal-combustion engines for United States war vessels. During the World War he was engineer of the bayonet department of the Remington Arms Co., and works manager of the Bullard Machine Co., both at Bridgeport, Conn.

Business Notes

The Ramsey Chain Co., Albany, N. Y., announces that the Morse Engineering Co., St. Louis, Mo., has just been appointed agent for the Ramsey chains in St. Louis territory.

The Fisher Governor Co., Inc., Marshalltown, Iowa, manufacturer of power-plant specialties, is adding a new unit to its plant, which will be the third addition in the past eight years.

The Conveyors Corporation of America, 326 West Madison St., Chicago, Ill., announces the appointment of the Thermal Efficiency Co., Scarritt Bldg., Kansas City, Mo., as its district representative.

The Pennsylvania Pump & Compressor Co., Easton, Pa., announces that the Kilner-Mills Co., General Motors Bldg., Detroit, Mich., is its representative for the State of Michigan and northwestern section of Ohio.

The Walworth Manufacturing Co., Boston, Mass., manufacturer of valves, etc., has decided to enter the Buffalo field in a more extensive way and has established a branch office there which will be in charge of Fred J. Chittenden.

The Schubert-Christy Construction & Machinery Co., representatives of manufacturers of power-plant equipment, is planning to install eight complete oil burners with service tanks, pumps, heaters, etc., at the Jefferson Barracks, St. Louis, Mo.

The Whiting Corp., Harvey, Ill., builders of cranes, gate hoists, and special machinery for water-power plants, have established a separate department for handling installations for headgates, sluice gates, etc., which will be in charge of A. H. Johnson, formerly with the Dominion Bridge Co. of Canada.

The Elliott Co., Jeannette, Pa., manufacturer of power-plant specialities and agent for the Lagonda Mfg. Co., Pittsburgh, Pa., announces that F. C. Angle and N. L. Griffin are now connected with its Chicago office; J. N. McClure with the Philadelphia office; W. S. Myton has been sent to the Pittsburgh office; L. M. Forncrook has been retained in the condenser engineering department at Jeannette. These gentlemen have recently finished a year's apprentice course in shop, engineering and sales departments of the company at Jeannette.

The Link-Belt Co., 910 South Michigan Ave., Chicago, Ill., announces some changes in organization made necessary by the acquisition of additional plants and extension in the business. Charles Piez, formerly president of the company, has become chairman of the board and of the executive committee; Alfred Kaufman, formerly second vice-president was elected president and takes general direction and supervision of operations and sales and will remain for the present in Indianapolis; Staunton B. Peck becomes senior vice-president and supervises operations and sales in the Eastern district; Arthur C. Johnson was elected to the position of second vice-president and remains in charge of the Western district; Humphrey J. Kiely, elected third vice-president, continues in charge of exports and sales in the New York district.

Trade Catalogs

Drill—Chicago Pneumatic Tool Co., 6 East 44th St., New York City. Bulletin No. 896 describes the Little Giant electric hammer drill.

Blowers—Buffalo Forge Co., Buffalo, N. Y. Leaflet describing the variable speed electric blowers with new inclosed regulators manufactured by this company.

Valves—Yarnall-Waring Co., Chestnut Hill, Pa. Bulletin B 410-A contains a presentation of the different types of blowoff valves for high-pressure boiler service, manufactured by this company.

Refractories — Norton Company, Worcester, Mass. Booklet, "Norton Refractories for Heavy Duty," with descriptions of "Alundum" and "Crystolon" the types manufactured by this company can be had by writing the manufacturer.

Pumps—Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Catalog No. 1632-G is a well-illustrated presentation of the capacities, merits and uses of these centrifugal pumps and centrifugal pumping units, and includes tables of capacities and friction.

Valves—The Chapman Valve Manufacturing Co., Indian Orchard, Mass. Catalog No. 38 is a small, cloth-bound book containing 344 pages of descriptive matter and illustrations of valves, fire hydrants, indicator posts, sluice gates, floor stands, etc. Tables of dimensions, price lists, and valuable data are included. A handy desk catalog.

Coming Conventions

American Chemical Society. Dr. Charles L. Parsons, 1709 G St., N. W., Washington, D. C. Sixty eighth meeting at Cornell University, Ithaca, N. Y. Sept. 8-13.

American Electric Railway Association. James W. Welsh, 8 West 40th St., New York City. Meeting at Atlantic City, Oct. 6-10.

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Oct. 2-4.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meeting at Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

British Association for the Advancement of Science at Toronto, Canada, Aug. 6-13.

Exposition of Inventions. American Institute, 47 West 34th St., New York City. Exposition to be held in the Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Franklin Institute of Pennsylvania, Centenary Celebration at Philadelphia, Sept. 17-19.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention at Detroit, Mich., Sept. 8-13.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids. **Pennsylvania State Association** at Grand Rapids, Mich., Sept. 8. J. N. Calvert, Union & Ridenour Ave., Crafton, Pittsburgh, Pa.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Safety Council. W. H. Cameron, 168 N. Michigan Ave., Chicago, Ill. Thirteenth Annual Safety Congress at Louisville, Ky., Sept. 29 to Oct. 3.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Universal Craftsmen Council of America. John F. Amos, P. O. Box 299, Rochester, N. Y. Meeting at Hotel Sherman, Chicago, Ill., Aug. 5-8.

Relays—Roller-Smith Co., 233 Broadway, New York City. Bulletin No. 550 describes with illustrations relays for overload, reverse current, under-load, over-voltage, under-voltage and time limit.

Cement, Refractory — Harbison-Walker Refractories Co., Pittsburgh, Pa. Catalog describing "Thermolith," an all-temperature fire cement, includes a comprehensive treatise on the value and application of this cement in the various industries and includes proofs and tests together with data relating to its performance.

Packing, Metallic—Wm. B. Merrill & Co., 3368 Washington St., Boston, Mass. The Tripp metallic packing is described in a well-illustrated and printed catalog which can be had by writing to the manufacturer. The packing rings depicted are susceptible of adjustment to any slight variation of the rod and are suitable for piston rods and valve stems of stationary and marine engines, pumps, compressors, etc.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 28, 1924		July 21, 1924
Pool 1	New York	$2.50	@$2.90	$2.70
Smokeless	Columbus	2.00	@ 2.25	2.20
Clearfield	Boston	1.45	@ 2.30	1.85
Somerset	Boston	1.65	@ 2.40	2.00
Kanawha	Columbus	1.35	@ 1.60	1.45
Hocking	Columbus	1.60	@ 1.80	1.70
Pittsburgh No. 8	Cleveland	1.80	@ 1.90	1.80
Franklin, Ill.	Chicago	2.25	@ 2.50	2.35
Central, Ill.	Chicago	2.00	@ 2.25	2.10
Ind. 4th Vein	Chicago	2.25	@ 2.50	2.35
West Ky.	Louisville	1.50	@ 1.75	1.60
S. E. Ky.	Louisville	1.35	@ 1.75	1.55
Big Seam	Birmingham	1.50	@ 2.00	1.75

FUEL OIL

New York—July 31, light oil, tank-car lots, 28@34 deg. Baumé, 4¾c. per gal., 36@40 deg. 5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis — July 15, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.60 per bbl.; 28@30 deg., $1.65 per bbl.; 30@32 deg., $1.75; 32@36 deg., gas oil, 4.5c. per gal.; 38@40 deg., 5.5c. per gal.

Pittsburgh—July 24, f.o.b. local refinery, 30@40 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 8¼c. per gal.

Dallas—July 28, f.o.b. local refinery, 26@30 deg., $1.25 per bbl.

Philadelphia—July 18, 28@30 deg., $2.05@$2.113 per bbl.; 18@22 deg., $2.075@$2.139; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—July 25, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4⅝c. per gal., light oil, 28@32 deg. Beaumé, 6⅝c. per gal.

Cincinnati—July 28, tank-car lots, gal., light oil, 28@32 deg. Baumé, 4⅜c. per gal.; 26@30 deg., 4½c. per gal., 30@32 deg., 5c. per gal.

Chicago—July 22, 20@22 deg., 5½c. per gal.; 24@26 deg., 6c. per gal.; 28@30 deg., 6½c. per gal.

New Plant Construction

Calif., Bartle—The Pacific Gas & Electric Co., 445 Sutter St., San Francisco, awarded a contract to Moore Dry Dock Co., Adeline St., Oakland, for steel penstock for Pit River Development No. 3.

Calif., Fullerton—Union High School District is having plans prepared for a swimming tank, to be equipped with filtration system, water heaters, pumping plant, etc. C. M. Winslow, Van Nuys Bldg., Los Angeles, Archt.

Calif., Hollywood—The Hollywood-California Hotel Corp. awarded a contract to The Foundation Co., 120 Liberty St., New York, for the construction of the new Hollywood-California Hotel on Hollywood Blvd., including iceless refrigerators, circulating ice water, central heating in winter and central cooling in summer. Estimated to cost $3,000,000.

Calif., Merced—Merced Irrigation District, R. V. Meikle, chief engineer, awarded a contract to Bent Bros., 418 South Pecan St., Los Angeles, for the construction of Exchequer Dam and Power House. Cost $2,452,079. Noted July 29.

Calif., Palo Alto—The City plans election to vote bonds for $46,000 to finance enlarging capacity of municipal power plant.

Calif., Santa Barbara—The City plans an election to vote bonds for a hydro-electric plant for municipal power and lighting to cost approximately $100,000. G. D. Morrison, city engineer.

Calif., San Francisco—Merchants Ice & Cold Storage Co., Battery & Lombard St. awarded a contract to H. Larsen, 747 Monadnock Bldg., for cold storage and ice plant on Lombard St., to cost $400,000.

Colo., Canon City—The Southern Colorado Power Co., is building an $80,000 boiler house at its Soda Point plant near here.

Conn., Bridgeport—The United Illuminating Co., 1115 Broad St., awarded a contract to Casey & Hurley, 120 Pequonock St., for addition to their Steel Point Station, including boiler room, turbine generating room and switch house. Westcott & Mapes, Inc., 139 Orange St., New Haven, engineers. Noted July 29.

Conn., New Britain—State Board of Education, Hartford, awarded a contract to M. J. Daley, 543 Bank St., Waterbury for boiler house and coal pocket at State Normal School on Prospect St., here. Alfred Kellogg, 89 Franklin St., Boston, is architect, and W. F. Brooks, Hartford, engineer.

Ill., Centralia—The City Council is having plans prepared for filtered water reservoir, headhouse, etc., including two 3,000,000 gal. steam turbines, and one 5,000,000 gal. steam turbine, low lifts. Estimated to cost $125,000. Pearse, Greeley & Hanson, 6 North Michigan Ave., Chicago, engineers.

Ill., Chicago—The City Council will receive bids about Aug. 15th for two steam turbine centrifugal pumps, 70,000,000 gals. capacity each in 24 hrs. One for Central Park Ave. pumping station, and one for Springfield Ave. pumping station. John Ericson, 402 City Hall, city engineer.

Ill., Elgin—The City Sanitary District will receive bids until Aug. 20 for sewage disposal plant, including pump house, pumping equipment, tanks, etc., estimated to cost $420,000. Pearse, Greeley & Hanson, 6 North Michigan Ave., Chicago, engineers.

Ind., New Castle—The City Council, had plans prepared, and will receive bids until Aug. 15, for addition to waterworks, including large centrifugal pump.

Kan., Brookville — L. R. Martin, City Clerk, will receive bids until Aug. 7 for waterworks, including one deep well 2 stroke pump, 30 g.p.m., pump house, etc. Ruckel Engineering Co., Hutchinson, Kan., consulting engineers.

La., Cheneyville—The Town, address F. P. Joseph, Consulting Engineer, Glenmore, plans an electric light and water plant, to cost approximately $40,000.

Md., Baltimore—Mt. St. Agnes College, Mt. Washington, awarded a contract to Frainie Bros. & Haigley, 19 West Franklin St., for power house and laundry building. Estimated to cost $85,000. Frank J. Baldwin, 328 North Charles St., is architect. Private plans.

Mass., Boston—Department of Public Works, Sewer Division, City Hall, plans new sewers and machinery at Calf Pasture Pumping Station.

Mass., Boston — The Eastern Steam Laundry Co., Chicago, Ill., have commissioned Lockwood, Greene & Co., 38 S. Dearborn St., Chicago, Ill., engineers, to design and supervise the construction of boiler house and garage at their plant here. Cost to exceed $40,000.

Mass., Forest Hills—(Boston P. O.)—Boston Elevated Railway Co., Park Square Bldg., Boston, awarded a contract to McDonald & Imhof, 164 Dudley St., Roxbury, for garage and boiler plant here. Estimated to cost $90,000. A. J. Blackburn, c/o owners, is engineer. Noted July 22.

Mass., South Boston—Gillette Safety Razor Co., 41 West 1st St., is receiving bids for a new power plant, cost to exceed $40,000. Charles T. Main, 200 Devonshire St., Boston, engineer.

Mich., Detroit—A. Cohn, 2615 Woodward Ave., is having plans prepared for an apartment house on Second Ave., and Peterboro St., estimated to cost $1,500,000. Steam heating equipment with oil burners will be required. A. F. Herman, 710 Owen Bldg., architect.

Mich., Detroit—Peoples Outfitting Co., Michigan Ave., is having plans prepared for two 12 story mercantile buildings including steam heating equipment, one on Shelby St., and one on Michigan Ave. A. Kahn, 1000 Marquette Bldg., is architect.

Minn., Brainerd—Northern Pacific Railroad Co., Railway Bldg., 5th & Jackson Sts., St. Paul, awarded a contract for the construction of a power house here to Charles Skooglun, c/o owners, St. Paul.

Minn., Owatonna — The City awarded a contract to Donovan Construction Co., 417 Commerce Bldg., St. Paul, for complete steam power plant, building and equipment, including two 600 kw. bleeder type turbines, two 300 hp. boilers stack switchboard, etc., also complete electric distribution and street lighting system. Bids for complete underground steam heating system were rejected. Cost $263,900. A. L. Mullergren, 555 Gates Bldg., Kansas City, Mo., is engineer, and Jacobson & Jacobson, 412 Oak Grove, Minneapolis, are architects.

Mo., St. Louis—The City received lowest bid for construction of Union Market at Broadway & 6th Street from Fruin Colnon Contracting Co., Merchants Laclede Bldg., estimated cost $850,000. Bids will be taken later for refrigeration machinery. H. Updike & L. R. Bowen, 301 City Hall, are engineers.

Mo., Washington—The City, R. Steinhaus, City Clerk, will receive bids until Aug. 7, for waterworks improvements, including 250,000 gal. water tank, etc., bids on pumping equipment to be received at a later date. W. R. Rollins & Co., 521 Railway Exchange Bldg., Kansas City, engineers.

Mo., Waynesville — Central Missouri Power & Water Co., 700 Interstate Bldg., Kansas City, having preliminary plans prepared for dam 95 ft. high, forming lake one mile wide and 50 miles long, main power house, 7,000 hp. turbines, each operating 5,000 kw. electric generator. Clark E. Jacoby Engineering Co., 700 Interstate Bldg., Kansas City, engineers.

O., Cleveland—The Cleveland Illuminating Co., Illuminating Bldg., W. H. Hartman, Purch. Agt., will purchase three 1,500 hp. boilers for powdered coal, ash conveying equipment, feed water heater, motors, radial brick stacks 300 ft. high, for 4500 h.p. high pressure steam plant at 1800 Lakeside Ave.

Okla., Avant—The City Council, plans new election to vote bonds for $23,000 for pipe lines, pumps, etc., Bonds were defeated at recent election.

Okla., Idabel—The City Council, plans enlarging its present water supply system, including pumping equipment. V. V. Long & Co., 1309 Colcord St., Oklahoma City, is engineer.

Pa., Johnstown—The Bethlehem Steel Co., Bethlehem, plans 18,000 kw. capacity power plant here. Estimated to cost $200,000. A. T. Keller, Corp. Engineer, c/o owner.

S. D., Watertown—The City, W. F. Cochrane, City Engineer, is receiving bids for gas-engine driven diaphragm trench pump, 12,000 gals. per hour capacity, complete with truck and suction hose.

Tenn., Bluff City—The City, A. J. Geisler, Mayor, will receive bids until Aug. 4 for water distribution system, pumping equipment, etc.

Tex., Asherton — J. McMahon, Travis Bldg., San Antonio, has just purchased the Asherton & Gulf Railway, and will extend lines from Asherton to Carrizo Springs and to Eagle Pass. Large ice plants to store vegetable shipments will be constructed at Asherton and other places.

Tex., Lufkin—The City has voted bonds for $75,000 to finance new waterworks system, mains, power house and pumping equipment etc.

Tex., McKinney—McKinney Ice & Coal Co., Thos. E. Craig, Mgr., plans to purchase one 40 to 50 ton distilled water ice plant complete, less boilers, one 100 kw. 3 phase, 60 cycle, 220 to 240 v. steam-driven generator and panel, one steam driven air compressor to lift 100 gal. per min. at a working air pressure of 200 lbs. per sq.in. All equipment to operate at 115 to 125 lb. steam pressure non-condensing.

Tex., Putnam—The City plans and election to vote bonds for $35,000 to finance improvement to water works, including new pumping equipment, larger power house and additional mains. B. Clinton, Commissioner.

W. Va., Elkins—The Bd. of Trustees, will receive bids until Aug. 26, for construction of Davis and Elkins College buildings including central heating plant. Walter F. Martins, Charleston, is architect.

Wis., Madison—The City, c/o. L. A. Smith, Supt. Waterworks, plans erection of steel water tank of 20,000 to 25,000 capacity on 75 ft. tower and deep well pumping equipment, estimated to cost $15,000.

Wis., Mokwonago—A. E. Austin, clk., will receive bids until Aug. 5 for two centrifugal pumps in connection with waterworks and sewage improvements. Robert Cramer, 1105 Vliet St., Milwaukee, is engineer.

Wyoming—The Midwest Refining Co., 1st National Bank Bldg., Denver, Colo., is building a large electrical power plant in the Salt Creek oil field of Wyoming. There will be erected approximately 200 derricks, each will be equipped with an electric motor to propel a pump at every oil well that has not sufficient gas pressure to force the oil in the proper manner.

N. Z., Arapuni—Department of Public Works, awarded a contract to W. G. Armstrong, Whitworth & Co., London Eng., for Arapuni hydro-electric plant on Waikaro River including dam, power house, turbines, electrical machinery, etc., here. Cost $5,878,200.

N. Z., Eltham—The Taranaki Electric Power Bd. will receive bids until Oct. 7 for 74 transformers, for hydro-electric stations, at a pressure of 6,600 v. 3 phase, 50 cycles to 400 v. 3 phase for distributing on 4 wire system, stepping up to and down from 33,000 v.

N. Z., Wellington—Department of Public Works will receive bids until Oct. 28 for Lake Colendge Power Scheme as follows—main switchboard complete with all accessories, temperature indicator panel, voltage regulator panel complete, 1 set bus reactors, signalling system complete, oil switches, complete with enclosures, insulating links, bus-bar and connections, cables, oil-switch spares as follows; six 600 v. 300 amp. generator oils switches, two 6,600 v. 600 amp. generator oil-switches, three 6,600 v. 300 amp. feeder oil-switches, complete with accessories, one spare oil-switch, 600 amps. complete with specified spares.

Ont., Hamilton—Brennan Paving Co., Ltd., Melrose Ave., will purchase 40 hp. locomotive type boiler, preferably on wheels.

Ont., Toronto—Ravina Rink Co., Rowlands Ave., had plans prepared and will soon purchase equipment for artificial ice rink, estimated to cost $150,000. Ewart, Jacobs, Armer & Byam, 36 Toronto St., engineers.

Sask., Regina—The City Commissioner will receive bids until September 2nd., for one 5000 kw. steam turbine generator, 3 phase, 60 cycle, 2300 to 4000 v. and one surface condenser for 70,000 lbs., steam per hour and 29 ft. vacuum.